THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE IV. VOL. III.

No. XII.—DECEMBER, 1896.

ORIGINAL ARTICLES.

I.—Some Notes on the Aptychi from the Upper Chalk.

By H. P. Blackmore, M.D., F.G.S.

(PLATE XVI.)

IN 1853–6, when Mr. Sharpe published his monograph on the Cretaceous Cephalopoda of England, the various species were roughly placed according to the divisions of the Chalk formation as described by Conybeare and Philips. This, unfortunately, led to many mistakes: amongst others, Mr. Sharpe described *Belemnitella mucronata* as occurring "everywhere in the Upper Chalk of the South of England," whilst *Belemnitella quadrata* is only noticed as occurring in the Middle Chalk of Kent, Surrey, and Sussex; the fact being that *Belemnitella quadrata* is not found in the Middle Chalk, and *Belemnitella mucronata* is restricted to the highest zone of the Upper Chalk.

A careful study of the various Chalk beds by Barrois, Whitaker, Price, Evans, and others has resulted in establishing the fact that the Upper Chalk, which to the casual observer looks all alike, can be easily subdivided into various zones, each zone being characterized by the presence of certain typical fossils, amongst which the Belemnites play an important part. In the upper beds are found *Belemnitella mucronata*; these are immediately followed by others containing *B. quadrata*, and in the lower third of this zone is a small band which contains *B. lanceolata*; whilst still further down in the Marsupite zone is found the small *B. vera*.

UPPER CHALK ZONES IN THE NEIGHBOURHOOD OF SALISBURY.

1	100 feet	*Belemnitella mucronata* zone
2	150 feet	*Belemnitella quadrata* zone
		Belemnitella lanceolata band
3	200 feet	Marsupite zone with *Belemnitella vera*

In the neighbourhood of Salisbury, the zone of *Belemnitella quadrata* is largely developed, as well as the smaller, more limited bed which contains *Belemnitella lanceolata*: a carefully-collected series of fossils from these two zones soon brought out the fact that *Aptychus leptophyllus* and *Belemnitella lanceolata* always occurred together, and that *Aptychus Portlockii* and *Belemnitella quadrata* were similarly associated. A further study of the specimens themselves revealed what this probably meant, viz., that these two Aptychi were the forward extension of the phragmocone, called by Huxley the pro-ostracum, of *Belemnitella lanceolata* and *Belemnitella quadrata* respectively. Let us now examine more closely and see whether the facts bear out this interpretation, and, for the sake of convenience, begin with *Aptychus leptophyllus*, as related to *Belemnitella lanceolata*.

If a specimen of the latter, sufficiently well preserved to show the form of the alveolar opening of the guard, be carefully examined, it will be noticed that the lateral curve of the anterior edge exactly fits the posterior end of *Aptychus leptophyllus*; and further, that these corresponding edges are similarly ended by roughened margins (Figs. 1 and 2); also, on the inner surface of the outer margin of the proximal end is a well-marked curved line (more apparent in some specimens than others), evidently caused by a fold of membrane which attached this part of the shell to the latero-dorsal end of the alveolus. The semi-crystalline structure and mineral condition of *Aptychus leptophyllus* are identical with the alveolar lining of *B. lanceolata*, both differing from the structure of the guard, corresponding in this respect with the analogous structure of the conotheca of *Belemnites paxillosus*, *B. inornatus*, and *B. ellipticus*, from the Lias and Oolite; furthermore, the singular and characteristic curves on the surface of the conotheca of the first of these species closely resemble the well-marked curved lines of growth seen on the inner concave surface of *Aptychus leptophyllus*. The outer surface of the proximal end of most of the aptychi shows distinct marks of lamination, indicating the secretion of successive layers of shell, deposited by the membrane as the animal increased in age.

This is an important point to notice, as it clearly proves that the shell grew from this end of the aptychus, and not from the straight lateral edge, as would have been the case if these aptychi represented the opercula of Ammonites. The well-marked curved lines of growth on the inner concave surface, as well as the direction of the few radiating longitudinal lines, also prove the same point.

The outer surface of the aptychi is smooth, convex, and thickened towards the outer edge, which in a side view presents a double curve; the distal end is terminated by a thickened, rounded, smooth ridge. The straight inner side is very thin, sharply curved inwards at its margin; some specimens from the Salisbury chalk-pits show the two halves united along this margin, one lapping over the other, the junction forming a straight groove which was probably a continuation of the ventral sulcus or the siphuncle.

The alveolar end of the guard of *B. lanceolata* is generally much paler in colour than the rest of the guard; but at about a quarter of

an inch from the free margin there is a well-marked stain of darker colour which follows the contour of the alveolar margin; this is so constantly present in well-preserved specimens that it is probably due to, or marks a point of attachment of, the membrane which united the pro-ostracum to the phragmocone. This darker marking can also be observed along the outer and upper curved margin of the aptychus.

The roughened termination of the thin alveolar margin, and corresponding irregularity of the proximal end of the aptychus, have been already noticed; from this it would appear there was no fixed shelly attachment of the pro-ostracum to the phragmocone; the union was one of membrane only, which would have allowed a considerable amount of movement to this portion of the shell of the Belemnite. This is also probably the reason why the aptychi in the Chalk are not found attached to the guard; the membranes would speedily decompose after death, and in decaying become separated from the heavier guard, which from its shape and weight would naturally sink to the bottom of the ocean, whilst the membranes containing the head, arms, and pro-ostracum would float away and be deposited probably far away from the guard.

One other point is worthy of note, viz. what one might term the suitability in point of size and shape. Fig. 4 represents the largest and Fig. 5 the smallest specimen found: both can be readily fitted to appropriate guards from the same bed of Chalk; whereas they would be utterly out of proportion as opercula of the huge *Ammonites leptophyllus*, which is also found in this locality, but in a much lower zone.

In the Marsupite zone of this neighbourhood Mr. Jebbett has, however, met with a fragment of a very different and much thicker, coarser aptychus, with numerous prominent points which project nearly an eighth of an inch from the external convex surface. My thanks are due to Mr. G. C. Crick for drawing my attention to several nearly perfect specimens from Charlton and Bromley, in Kent (Nos. 46,770, 48,741, 70,391), in the Natural History Museum, Cromwell Road, in every respect corresponding with a broken specimen from Salisbury. These aptychi are very different from those already described in this paper, and, from their size and the fact of their occurring in the Marsupite zone, they may be fairly assigned to *Ammonites leptophyllus*; certainly they could not belong to any Belemnite.

In the same zone of Chalk in which is found *B. lanceolata* and its pro-ostracum, have been discovered specimens of rhyncholites, which there is good reason for considering the beak of this Belemnite; no Ammonite or Nautilus being known in this zone at this locality. Two views of the upper mandible of a large Salisbury specimen are given in Pl. XVI, Figs. 6, 7.

Belemnitella quadrata differs in so many respects from *B. lanceolata* and *B. mucronata*, both in the shape and proportion of the alveolar cavity, as well as in the size and granular surface of the guard, that one is not surprised to find how widely the small aptychi which

Mr. Sharpe described in the Memoir of the Palæontological Society under the name of *Aptychus Portlockii*, differ from the pro-ostracum of *B. lanceolata*. There is, however, to be noticed the same appropriate correspondence in regard to size, between these small aptychi and the small contracted alveolar opening of *B. quadrata*; the largest specimen measuring in length 18 mm. and the smallest only 7 mm. The straight inner edge is very different from that of *Apt. leptophyllus*, being bent into an angular process which laps over the similar projection of the other shell—generally the left laps over the right—and when thus united they form on the inside a groove which corresponds with the internal groove previously described in the pro-ostracum of *B. lanceolata*. (See Figs. 10–12.)

There is no evidence how these small pro-ostraca were attached; but probably the attachment was loosely by membrane, not so near the guard as in *B. lanceolata*, and hence were even more easily detached and separated from the guard after the death of the Belemnite.

No trace of mandibles has been hitherto found associated with *B. quadrata*; the beak was possibly horny and not of the same composition as the guard or pro-ostracum, hence it was not preserved, and has left no trace behind.

After having established the fact of the relationship of *B. lanceolata* and *B. quadrata* to the two aptychi found with them, attention was paid to the higher zone of the Chalk, and here it was discovered that *Aptychus rugosus* was associated with *B. mucronata*. As the guard and alveolar cavity of this species bear a close resemblance to the same parts of *B. lanceolata*, so *Aptychus rugosus* in many ways—in outline, general form, and relative size—resembles *Apt. leptophyllus*. There is the same thin, straight inner edge curved to lap over the margin of its fellow shell, and the curved lines on the inner concave surface are nearly identical. Externally, as the specific name indicates, the surface is marked with a series of roughened ridges, arranged in irregular parallel lines, which somewhat follow the outline of the upper and outer sides of the shell; these tuberculated ridges do not extend to the outside, which is terminated by a thin, flat, bevelled edge. The peculiar sculpturing of the external surface is probably due to the impression made by the roughened membrane which originally covered this extension of the phragmocone, and bears a close resemblance to the granular surface, so often seen on the guard of *B. quadrata*, and also very marked in the upper part of the guard of a large specimen of *B. mucronata*, from Westphalia, in the Natural History Museum, Cromwell Road, which is undoubtedly secreted by the membrane covering it.

Briefly, therefore, it appears that—

(1) *Aptychus rugosus* is the pro-ostracum of *Belemnitella mucronata*.

(2) *Aptychus leptophyllus* is the same part of *Belemnitella lanceolata*.

(3) *Aptychus Portlockii* is the pro-ostracum of *Belemnitella quadrata*.

(4) The large, coarsely punctate aptychus from the Marsupite zone is the true *Aptychus* of *Ammonites leptophyllus*.

It is consequently proposed that in future, as far as the first three are concerned, the term aptychus be omitted, the fossils being named after the several Belemnites of which they form a part.

EXPLANATION OF PLATE XVI.

1. Lateral view of guard of *Belemnitella lanceolata*, showing curve of alveolar margin, and the dark stain parallel to it.
2. External view of *Aptychus leptophyllus*, showing the smooth thickened ridge on upper and outer edge, and also laminated lower edge.
3. Internal view of same, showing the curved lines of growth, and curved line produced by membrane on the lower outer edge.
4. External view of largest specimen of *Apt. leptophyllus*.
5. Internal view of smallest specimen of *Apt. leptophyllus*.
6. Front view of *Rhyncholite*, the upper mandible of *Bel. lanceolata*.
7. Lateral view of the same.
8. External view of *Aptychus Portlockii*—the right perfect half, the left broken on inner edge.
9. External view of an example of *Apt. Portlockii*; the surface is nearly smooth, showing but few lines of growth.
10. External view of a specimen of *Apt. Portlockii*, slightly broken on inner and lower edges; lines of growth strongly marked.
11, 12. Two small examples of *Apt. Portlockii*, the two halves united on the inner margin at an angle which corresponds with that of the alveolar cavity of *Belemnitella quadrata*.
13. Internal view of right side of *Apt. Portlockii*, showing regular lines of growth.
14. Dorsal view of a part of guard of *Bel. quadrata*, showing the form of alveolar cavity and the curve of alveolar edges.
15. Lateral view of the same.
16. External view of a large specimen of *Aptychus rugosus* from the Upper Chalk, Norwich.

All the illustrations of *Bel. quadrata* and *Apt. Portlockii* are magnified two diameters, save Figs. 14 and 15, which, like the other figures, are of the natural size. The specimens are in the author's cabinet, Vale House, Salisbury.

II.—The so-called Middle Sands and Glacial Gravels of Eastern England.

By Sir Henry H. Howorth, K.C.I.E., M.P., F.R.S., F.G.S.

In a previous paper I have discussed the post-Tertiary Clays of Eastern England.[1] In that paper I endeavoured to show that these clays, varying as they do in texture, composition, and contents, mark a varying geographical distribution and substratum rather than a succession of changes in time; that, so far as we can tell, they are for the most part on the same horizon, and interlock with each other, with occasional local overlaps; while they are united by one common element, namely, the presence of certain foreign boulders of the same general type in them all.

These clays are closely associated with largely developed beds of sand and gravel, which present similar problems for solution, and to some hitherto neglected features of which I should like to call attention. Before turning to these sands, etc., I would, however, add one or two additional facts and quotations in reference to the clays in support of my former conclusion. In Norfolk an attempt has been made to separate the so-called glacial clays

[1] Geol. Mag., October, 1896, p. 449.

into a Lower Clay, consisting of a brown stony loam, and an Upper or Chalky Clay, overlain by sands and gravels; but the sections from which this attempted division has been deduced are very uncertain and doubtful in their testimony, and the best authority known to me on the surface beds of East Anglia, Mr. Horace Woodward, says of them: "Most of these sections show in the same pit the sand tapering away, and then the two Boulder Clays come together, and their separation is not a happy task." Again, he says that in many places the Lower and Upper Boulder-clay are identical in character. He further says that, while in East Norfolk the brown clay maintains its character of a brown stony loam, further west "the lower glacial clays become so like the Chalky Boulder-clay that, from the evidence of pit-sections, they cannot be separated one from the other." (Woodward's Geology, p. 507, and "Geology of Country round Fakenham, etc.," p. 19.) This geographical distribution of the two clays is at once explained when we map out the beds underlying the Drift in Norfolk, and find that in the eastern part of the county the Chalk is still covered and protected by Crag beds, and was not, therefore, accessible when the Drift was formed, while in West Norfolk the Crag is denuded, as are the other Tertiary beds, and the Chalk itself is exposed. This accounts for the chalky débris in the one clay and its absence in the other. Carvell Williams, in describing the surface beds of Lincolnshire, says: "Near Weston, three miles west of Louth, are good exposures of Hessle Clay banked against the Chalky Boulder-clay"; and he adds the pertinent question—"Does not the brown clay pass into the chalky clay?" Again, he describes at Bricket Wood, in Hertfordshire, a clay as precisely intermediate between the Hessle Clay and the great Chalky Boulder-clay, and adds, "It is clearly both." Again, Jukes-Browne wrote a well-known memoir proving the connection of the Lincolnshire clays with the Hessle clays of Yorkshire (Q.J.G.S. 1879, p. 397).

Let us now pass on. With the post-Tertiary clays, as I have said, are associated large beds of sand sometimes having a gravelly texture, and containing seams of gravel and of laminated brick-earth. These sands agree with the clays in containing the same kind of erratics, and are treated by the orthodox geologists, who champion an Ice Age, as glacial deposits.

As is well known, efforts were made long ago by Binney and Hull, working on different lines and coming to different conclusions, to arrange the so-called glacial beds of Lancashire into three series. Binney divided them into two sandy beds separated by a clay; while Hull, whose division has been more popular, into two clays separated by sands and sandy gravels.

To these sands and sandy gravels of Hull's arrangement was given the name of Middle Sands, because they were supposed to come between the two clays. This tripartite division has caused much heartburning among geologists, who have found it impossible to apply it to the great mass of the beds found outside of Lancashire, or even within that county, and especially has the difficulty been

felt in Eastern England, where no sophistication of the evidence enables us to apply such a division or any other yet suggested, and no one has been more emphatic in pointing this out than Mr. Horace Woodward. Speaking of the quadripartite division of Messrs. Wood and Harmer, he says (in reference to the area around Fakenham): "I have been at a loss to find the persistence of any of the above four divisions." The beds have "frequent and often very abrupt changes in lithological characters," etc., etc.

Every geologist known to me of any repute, and working in Eastern England, now repudiates the notion that it is possible to apply any of the plausible divisions which have been suggested to the surface beds of Eastern England; while most of them would agree with Professor Judd in his remarks on Leicestershire, Rutland, etc., that the sands and gravels pass horizontally into boulder-clay, and reject any classification of the beds based upon the alternation of clay with sand. The fact is, not only do the clays and sands run into each other and interlock, but the clays frequently contain pockets and lenticular masses of sand, in many cases of laminated sands with shells, while the sands contain similar patches of boulder-clay, showing they were contemporary or virtually so. Although the tripartite division has not been adopted, the term Middle Sands still figures largely in the literature of these deposits, and occupies a notable place in the index to the Quarterly Journal of the Geological Society.

The geologists of the Survey now generally separate the so-called glacial beds of Eastern England into two series, contrasted sharply by their matrix and texture, namely, the boulder-clays and the sands, etc. While the clays are treated as the remnant of some entirely hypothetical *moraine profonde*, the sands, which are often stratified and current-bedded, and which cannot therefore be attributed to this fantastic product of Cloudland, are assigned to the action of water. By some this water is supposed to have flowed from the glaciers or ice-sheets in the form of subglacial streams, and by others, who still maintain a tripartite or multiple division, to mark Interglacial climates.

First, a word or two on a critical difficulty for the Glacialists, suggested by the existence of sands and clays in separate and intercalated layers. Every true glacier moraine known to me consists of a perfectly heterogeneous mass of clay, sand, and stones, or of sand and stones mixed in the greatest confusion and quite unsorted. A glacier, or any great mass of solid ice, is incapable, by any known process, of sifting and separating the ingredients in its moraines into sands and clays. Whatever virtues we attribute to ground moraines, we cannot well suppose that the glacier could separate them into the two great constituents of the so-called glacial beds. If the sands and the clays were once mixed in a common mass of so-called "glacier muck," they must have been sifted by something, and that something is shown by the laminæ and current-bedding of the sands to have been water and not ice. Water is, in fact, invoked to account for the sands by the

ultra-Glacialists, but, if water arranged and deposited the sands, whence did it derive them? If it washed them out of the heterogeneous "muck" which formed the moraine, then the clays, no less than the sands, must have been in suspension in the water, and been deposited by it, and if deposited slowly they ought to show, which they do not, lines of continuous stratification. If they came from some other source than this, whence could they have come when the country was, according to hypothesis, either blanketed by ice or covered with the moraine stuff of the glaciers or ice-sheets. The dilemma seems complete. I have put it before, in my "Glacial Nightmare." Of course, I have received no answer. The creed of the Glacialists could not live an hour if its advocates did not persistently hide their heads in the sand, like ostriches, to avoid the most commonplace and every-day evidence. But let that pass.

To a large number of geologists, these so-called Middle or Glacial Sands of Eastern England still index a supposed Interglacial, mild period. It was, in fact, upon the evidence of these very sands that Searles Wood first based his postulate of mild periods in Glacial times. It was supposed to be evidenced by the presence of marine shells in these sands, which could not have lived when the North Sea was choked with its portentous ice burden; and Searles Wood's conclusion is still quoted in some quarters. But the whole induction was really based on a complete mistake of observation. The shells contained in these sands did not live contemporaneously with the deposit of the sands at all. My friend Mr. Horace B. Woodward has shown very conclusively that all the shells and fragments of shells found in the so-called Middle Sands of East Anglia are derivative, and all of those which were formerly supposed to especially distinguish a mild, Interglacial age are really Crag shells, and derived from rearranged Crag beds. This view is now shared by Mr. Clement Reid, who formerly opposed it.

I would carry Mr. Horace Woodward's induction much further. It seems to me that, so far as we have evidence, it extends to making, not only the East Anglian, but all the shelly deposits of Eastern England, which have been treated as original deposits of the Glacial Age, derivative.

I cannot see how it is possible to separate the isolated shelly beds at March, in Cambridgeshire, from the shell beds of East Anglia, with which they agree so much in texture and contents; while, if we turn to the Yorkshire beds the evidence of their derivative and pre-Glacial character is very marked. These shells occur in the so-called Basement Clay at Bridlington, very often with their valves united, in "transported masses of olive-grey sand and clay." Other similar shells occur at Dimlington in pockets of transported sand which still preserve their lamination, as was observed long ago by Sir Charles Lyell and Professor Hughes, and broken shells also occur there in the clay. Mr. Clement Reid and Mr. Lamplugh have shown that these shells occur, not *in situ*, but as transported boulders.

The beds in question were formerly boldly called Crag, a name

which ought never to have been dropped, for, so far as can be judged, they are the Yorkshire representatives of the Upper Crag beds in Norfolk, in which, as is well known, Arctic shells occur. It is noteworthy that the beds at Bridlington contain vertebrate remains from the Crag, Eocene, and older beds (Woodward's Geology, p. 499).

It would also seem that the shell beds at Kelsey Hill, near Hull, which are overlain by Boulder-clay at Speeton, where they occur below the Lower Purple Clay, and at Aby, near Claythorpe, in Lincolnshire, are also of late Crag age. I find that after I had written this Mr. Carvell Williams had suggested the same conclusion; and if it be sustained it enables us to solve a considerable difficulty, namely, how to account for the Norwich Crag having been such a local deposit as it has been hitherto deemed to be. It enables us to connect the East Anglian Crag, as Mr. Carvell Williams has done, with the fragments of Crag beds which have occurred on the coast of Scotland in Aberdeenshire and Nairnshire. We must remember that as we get further north we must expect the shells during the period of the Norwich Crag, as in our own time, to show a more and more Arctic facies. I am not sure, in fact, whether all the drift shells on the British coasts which have been treated as glacial are not derivative, and ought not really to be classed as equivalents of the later Crag shells of Norfolk.

With the disappearance of these shells from the category of true glacial débris, and with the proof that they are derivative, disappears the postulate of an Interglacial climate in so far as it has been based on the shelly sands of Eastern England. It also opens the way for an explanation of these sands very different to that usually adopted.

As I have said before, the opinion is now pretty general that all the clayey matrix of the so-called glacial clays of Eastern England is a derivative product, and that it is not, in fact, a clay ground down from argillaceous rocks *de novo* by whatever distributed and arranged the so-called glacial beds, but that it was ready-made clay when that instrument began its work. It was taken up ready-made from the various beds of clay exposed to its influence—in some places from the Kimeridge and Oxford Clays, in others probably from London Clay and the clays of the Plastic Series, and in others, again, from the so-called Chillesford Clays of the Crag deposits.

Everyone who has written in any detail on the subject, seems to allow that the clay which forms the magma or body of the Boulder-clays was derived from pre-existing beds of clay. This conclusion is, in my view, equally true of the so-called sands and sandy gravels. *The sands associated with the Boulder-clays of Eastern England are, so far as I know, all derivative also,* and were ready-made as sands when the instrument which laid down the so-called glacial beds began to operate. For the most part they are *rearranged Crag sands.* In part, also, they are probably rearranged sands of the Bagshot and Reading Series; these recent beds having, doubtless, before the denudation of the Fens occupied a much larger area in Eastern England than they do now.

In a very great number of cases where they have been mapped as glacial sands by the Geological Surveyors, I believe it has been through a mistaken notion that Crag sands or Bagshot sands must necessarily contain Crag or Bagshot shells, whereas a very large portion of those sands is barren, and they only become fossiliferous in places. In the Memoirs of the Survey for East Anglia, there are continual laments about the difficulty of separating the so-called Middle Sands or glacial sands from the sand beds of the Norwich Crag. Mr. H. B. Woodward, for instance, says in his memoir on the country round Norwich, in many places there is considerable difficulty in drawing a definite line between the glacial sands and the Norwich Crag where they do not contain foreign stones (*op. cit.*, p. 104). The explanation of the difficulty seems simple enough. There is no difference, except of arrangement, between these sands. The same sands, when they occur in horizontal or undisturbed beds, are rightly treated as Tertiary sands; when they have become contorted and dislocated, or mixed with foreign stones, they are classed as glacial sands, the fact being that they are then merely Tertiary sands *remaniés*. The so-called contorted drift is probably nothing more than a series of alternating Crag sands and laminated clays which have been twisted and contorted and subjected to violent alteration, and in some cases mixed with some erratic boulders. This mixing and tossing about constitute the sole testimony they offer to their not being true and normal beds of Crag, etc. The so-called Middle Sands or glacial sands of Eastern England have their equivalents on the other side of the North Sea,[1] where they are developed on a great scale, and may be studied in a much more effective and simple way, since they are not associated there with the clays which form such a prominent feature of our own surface beds. In Holland, from Brabant to the Helder, the surface beds which are classed as glacial, lie immediately on Crag beds, which are there developed on a great scale, while there are no beds of Secondary clay or chalk exposed which could supply the ingredients for making boulder-clays like our Chalky Clay, etc. These so-called glacial beds in Holland, therefore, consist merely of sands and pebbly gravels corresponding to the Middle Sands which we have been discussing, and consist there, as they do here, of rearranged Crag beds, with a certain mixture of erratic boulders, and nothing more. The matrix of the beds is of home origin, and simply testifies to the Crag sands and gravels having been taken up by some mighty engine, which has rearranged and tossed them about, just as our Secondary and Tertiary clays and sands have been taken up and similarly rearranged. Nor is there a tittle of evidence in these Dutch beds, other than the supposed ice-borne character of the erratics contained in them, to suggest ice-portage or an Ice Age.

To return to England—what the instrument was which tossed the sands and gravels about, formed the contorted drift, and generally rearranged them in this fashion, I hope to discuss on another

[1] My friend Mr. Harmer's paper on the Dutch surface beds had not been published when I wrote this, or I should have referred to it.

occasion. At present it will suffice to draw the same negative conclusion from the sands that we have already drawn in regard to the clays.

In my former paper I examined every feature of these clays in succession, and endeavoured to show that in no single one do these clays support the notion that they were formed or distributed by ice; but, on the contrary, when critically examined, their texture, contents, mode of occurrence, etc., are absolutely inconsistent with ice in any form having had to do with them.

If this be so with the clays, *a fortiori* is it so with the so-called Middle Sands. These sands are stratified, laminated, and false-bedded; they present all the features of subaqueous deposition and arrangement, and it is universally concluded that they were, in fact, deposited by water. The champions of the Ice Age save their consistency, as I have said, by postulating that the sands were either distributed and laid down by subglacial streams or during an Interglacial, temperate period. I have already discussed the latter issue. In regard to the former let me add one further argument. These sands and sandy gravels are distributed in a most erratic fashion—sometimes, but rarely, in the valleys, sometimes capping the hills, sometimes on the slopes. How subglacial streams could run about the country, irrespective of its drainage and surface contour, uphill and downhill, and deposit these beds as we find them, passes all belief. The fact is, that directly the Glacialist has secured his ice-sheet, and covered the land with it, he considers that he is entitled to postulate any kind of mechanical absurdity as having occurred under its shelter—to believe in the moving about under a portentous weight of hundreds of feet thick of slippery clay, and sliding pebbles, and disintegrated sands, as of ice, ground moraine; the running about of water up and down the country, contrary to and in spite of gravity. These are samples of what is commonly supposed to have occurred in the far-off days when ice was everywhere. In fact, with the intervention of these entirely imaginary ice-sheets we are naturally transported to an entirely imaginary world, and entirely imaginary operations of Nature.

While the ultra-Glacialists admit the deposition of the so-called Middle Sands by water, there is one feature developed locally in them which many of the prophets of ice attribute directly to ice-action in the form of floating bergs, or of the melting of subterranean ice, namely, the contortions which occur in the so-called contorted drift, and the curves and twists of the laminar beds of sand, etc. Upon these I must add a few words. I have spent many scores of days on the coasts and in the sand and chalk pits of East Anglia, and have drawn a good many sections there. Many a time have I wondered how it was possible for any human being who realizes what a grounded berg is like, and the kind of mechanical work it can do, to suppose that it could possibly fashion the *long-continuous, beautifully modelled curves* into which the sandy laminæ have been arranged, many of them extending for hundreds of yards

without any breach in the continuity of their graceful lines, in many cases twisted into various serpentiform curves, which are often reversed. How a solid, heavy mass of ice, pounding down upon soft débris, marked by delicate lines and laminæ, or pushing over it, could avoid pounding it into what the Americans call "muck," or could in any way arrange the curved laminæ of the contorted drift as we see it in the cliffs of Norfolk, is a stupendous mystery to myself and perhaps to many other people. How it would be possible, again, to either create or maintain such curves and lines by the collapse of portions of soft beds in consequence of the local melting of buried layers of ice, as some others have argued, is equally confusing. The unsophisticated student who has drunk at these orthodox geological wells should suspend his judgment on these conclusions until he has actually seen the gigantic swirls and figures of $\int$ curves, which are so frequent in the Cromer cliffs, or mapped out carefully a series of the layers all arranged in concentric curves round some lenticular or other nucleus, of which examples occur at every few yards in the cliffs. The fact is, such reasoning as I am criticizing is the despairing death-song of Uniformity as understood by some of Lyell's scholars.

Not less impossible to attribute to ice-action, as we have shown in previous papers, is the presence in some of these contorted beds of great masses, not only of solid chalk, but of loose and soft materials, of pockets of sand or lumps of shale, which have been taken up and redeposited with their fine laminæ undisturbed, and the shells in them unbroken and transferred as boulders into the beds in question. That grounded bergs or coast-ice should have performed this kind of work, is as credible to some of us as that Nasmyth's hammer should have come down on a raspberry sandwich and left the indigestible layers intact. I claim to have shown that in no single respect do the so-called Middle Sands, so far as I know them, either testify to the action of ice in any form or to the existence of glacial conditions when they were deposited, nor to the existence of Interglacial periods: conclusions which I share in, as far as East Anglia is concerned, with one of the ablest and most experienced prophets of Neo-Glacialism, Mr. Carvell Lewis.

Having dealt with the post-Tertiary clays and sands, we still have to consider another set of beds, associated with them in Eastern England and marked, like them, by the presence of foreign stones. These are the beds of gravel and shingle (for the most part clean-washed), and consisting, with the exception of the comparatively small proportion of erratics they contain, of smooth flint and quartzite pebbles of a lenticular or flat, oval shape, and occurring in many cases as caps to the hills or on their flanks. Many of these were formerly treated as gravels formed in subglacial streams or by interglacial rivers.

The opinion has been gradually gaining ground lately, however, owing to the admirable work of Prestwich, Searles Wood, Monckton, and others, that the pebbles in these shingle and gravel beds were all formed and smoothed as we find them long before the so-called

Glacial Age. With the contour of the country as we know it there are no rivers in Eastern England which either make or can make gravel or shingle, nor do we see whence the original stones could have been derived under present conditions for fashioning the pebbles. These pebbles are precisely like in form and in character to the pebbles occurring in the Bagshot and Reading beds. Where they occur in East Anglia, etc., in regular beds and undisturbed layers, as they do at Southwold and in other places, it seems to me that they actually represent Tertiary horizons. Where they occur mixed with foreign stones and disturbed, they form another instance to be added to those already quoted of Tertiary beds which have been *remanié* and redistributed by the same force and at the same time as the various Boulder-clays were distributed. Let us now sum up some conclusions—

1. A general and most important result from these arguments and facts, if they are sound, is, that whatever it was that mixed and distributed the soft surface beds of Eastern England, the Boulder-clays, so-called Middle Sands, and the gravels, *it had no part in manufacturing the ingredients out of which those beds were fashioned.* These ingredients, in so far as they were local, were already fashioned and ready to its hands. The clays were already there in the form of clay; the chalky, Oolitic, and Liassic rubble was there in the form of rubble; the polished flint and quartzite pebbles were there in the form and shape we now find them; and the shells were also there, having lived in the Crag seas.

2. What the instrument alone did which formed these beds as we know them, was to bring with it a certain number of foreign stones and to mix them with the ingredients already on the ground, and then to distribute the product as we find it distributed.

3. There is no evidence in these beds to justify our postulating a long process and a prolonged period as necessary for this work, such as the fashionable school of geologists postulate, who profess to account, not only for this mixture and distribution, but for the manufacture of the ingredients, by invoking the long-continued action of ice during an Ice Age. On the contrary, there is every ground for believing the process to have been rapid, and, if not sudden, to have been continuous and not intermittent.

4. There is no ground, so far as these beds or their contents are concerned, for invoking the intervention of ice in any form in their mixture and distribution, but every feature which marks them is at issue with their having been the handiwork of ice. The term glacial, therefore, applied to the clays, sands, and gravels in question, is inapplicable. It is quite time that the authors of this literature should put on their armour and sharpen their weapons, and instead of repeating the *obiter dicta* of their wildest prophets, should condescend to examine the facts and arguments which have been quoted against them and to reply to their critics.

III.—The Present Aspects of Glacial Geology.[1]

By T. Mellard Reade, C.E., F.G.S.

SINCE I joined this Society I have devoted special attention to Glacial Geology, commencing with an investigation of the Pleistocene deposits in the neighbourhood of Liverpool, and gradually extending my observations to adjacent areas, and finally generally to England, Wales, Scotland, and Ireland. I have therefore thought that the "Present Aspects of Glacial Geology" would form a fitting subject for my closing Presidential Address.

My first published papers deal mostly with the Low-level Boulder-clays and Sands, of which we possess an excellent development in Lancashire and Cheshire. Latterly I have extended my studies to the High-level Shelly Sands and Gravels, and Boulder-clays. These observations are noted in papers which have appeared in the Proceedings of the Geological Society of London, our own and the Proceedings of other societies, and in the Geological and kindred Magazines; consequently, though the work has been continuous and connected, it cannot be studied as a whole without considerable labour, which few would care to enter upon.

The object of my present address is to compress the leading facts into a convenient compass, and to bring out the salient results and conclusions as they bear upon the present position of the Glacial question.

The whole of the Lancashire and Cheshire plain, from the sea-level up to about 400 feet, and in places 600 feet, is covered by a continuous mantle of Boulder-clay and sands, broken only by areas where the Triassic or Carboniferous rocks protrude through it, either from the absence of original deposition or from after-denudation. This series of deposits I have called the Low-level Marine Boulder-clays and Sands. These clays, as a rule, contain distributed through them, in a greater or less degree, fragments of shells and some perfect ones. I myself have recorded forty-four species.[2] The majority of the shells are of species that now live in the adjoining seas, mixed with a few others of a more northern type, such as *Astarte borealis*, which may be considered the typical Boulder-clay shell of our neighbourhood. Occasional examples of more southern forms occur, such as *Venus Chione*. The *facies* of the shells does not lead one to think that they lived in water of a very low temperature. An examination of the Boulder-clays from several localities, notably from the cutting of the Seacombe Branch of the Wirral Railway, and from Cook's Lane, Great Crosby,[3] show that they sometimes contain, and probably more frequently than is known, a profusion of Foraminifera, which tell a story not very different to the molluscan remains.

On the other hand, throughout these clays, which are commonly

[1] Presidential Address to the Liverpool Geological Society, 1896–7, by T. Mellard Reade, C.E., F.G.S., F.R.I.B.A.

[2] Q.J.G.S. 1874.

[3] Proc. Liverpool Geol. Soc. 1894–5 and 1895–6.

used for brickmaking, there occurs a great variety of boulders and pebbles, of which those from the English Lake District predominate, consisting of Silurian grits and ashy rocks and lavas from the Volcanic Series, which, if not individually identifiable, are certainly so in the mass. The rocks individually identifiable are, firstly, Eskdale Granite and, secondly, Buttermere and Ennerdale Granophyre. Mixed with these are Carboniferous rocks and, in a lesser degree, Triassic sandstones and shales, the Keuper Marls being identifiable by the casts of crystals of chloride of sodium seen on their surface. Granites from the South of Scotland, and also Silurian greywackes, may be distinguished.[1] These rocks, with the exception of the granites, are almost invariably striated, and often intensely so, especially the Silurian grits. The Carboniferous limestones are sometimes drilled with holes by boring molluscs, and in one case I found a boulder well striated on one side, and bored at the top and sides with *Saxicava* with the valves perfect and still remaining in the burrows. From the sand washed out of some of the holes I obtained the fry of *Saxicava* and of *Mactra*.[2]

I have shown[3] that though consisting of Boulder-clay and sands, the character of the drift differs in various localities, being related to the nature of the rocks in the river-basins in which it occurs: in one, clay predominates; in another, sand. The sand may lie at the base, in the middle, or on the top, or in all these positions at once. In some places the basal clay is fuller of stones, mostly rounded pebbles, and is of a sandier and harder nature, so as in some few cases, as at Dawpool, on the River Dee, to stand vertically. There are also divisions in the clay in places like unconformity, but probably due to contemporaneous erosion.

A microscopic examination of the various samples of clay shows that the percentage of sand is commonly much greater than one would expect it to be.[4] The sand-grains, as a rule, are much worn and rounded, and no doubt they have commenced as rounded grains, in many cases being derived from the Trias, but they are often much more polished than any grains I have taken direct from Triassic sandstone, being perfectly smooth and transparent. Also, there are to be seen very minute polished pebbles of hard drift rocks. The shell fragments often, but not always, show signs of much attrition. These deposits rest upon a floor of Triassic or, in some cases, Carboniferous or Permian rocks, which have a system of valleys not always corresponding with the present orographic system.

The Drift has by filling up the valleys sometimes changed the pre-Glacial course of the rivers, so that in the case of the Mersey it now runs in the rock-channel at Runcorn Gap, instead of along the deeper rocky valley buried below the town of Widnes. The pre-Glacial scenery was deeper-cut and bolder than the usually soft

[1] Q.J.G.S. 1884.
[2] Nature, vol. xl, p. 246.
[3] Q.J.G.S. 1883, vol. xxxix, pp. 83–132.
[4] See Davies and Reade, Proc. Liverpool Geol. Soc. 1894–5. Reade, "Drift Beds of Moel Tryfaen": *ibid.*, 1892–3; etc.

outlines of the Boulder-clay country. There is also evidence from the depth of these buried valleys that the pre-Glacial and, perhaps, early Glacial land stood much higher with respect to the sea-level than at present.

When the Boulder-clay, and in some cases the sand, is cleared from the surface of the rock, when this is of hard compact stone, striæ are pretty sure to be found, having usually a north-westerly trend, but with considerable variation and, in most cases, divergent, or even in some cross, striations. At Little Crosby the surface of the rocks was so ice-dressed that the mason who erected the village cross thought it unnecessary to chisel the top surface, upon which at the present moment deep and fine ice striæ are to be observed.[1] Extending our observations beyond the immediate neighbourhood of Liverpool, we find along the Welsh coast as far as Nevin, in Carnarvonshire, a similar assemblage of rocks and shells occurring in the Low-level Boulder-clays and Sands, intermixed to a greater extent with local rocks. These deposits show in some cases decided evidences of stratification. In addition to local differences in the clays the Welsh Low-level Marine Boulder-clays rest generally on another clay, which I call "till," which is distinguished by its assumption of the colour of the local rocks from which it is derived and on which it rests, and the absence of shells and far-travelled erratics.

This deposit bears a relation to the orography of the country, and is present in greatest force in the hilly and mountainous districts, where it can be traced in stream courses far up the valleys. The boulders are of rocks belonging to the immediate watershed, and are found both rounded and striated, angular and subangular. In the case of the larger valleys like the Vale of Clwyd, the marine drift penetrates further inland, but even at Rhuddlan it is seen to rest on a more local clay.[2] These marine deposits are in some cases continuously connected with the High-level Shelly Drifts, which occur at from 1,000 to 1,200 feet, as in the range of hills extending from Minera to Llangollen.[3] This connection may be traced from Ruabon up to the High-level sands just mentioned; also up the course of the River Alyn from its mouth to its source, and again down the continuing Vale of Afon Chwiter by Caerwys to the Vale of Clwyd. In this connection it has been necessary here to mention the continuity of the Low-level and High-level Drifts, though I shall have to recur again to the latter.

To the eastward the Marine Boulder-clays are traceable to Macclesfield, where they occur at a level of about 600 feet in what are known as the Cemetery beds, and an outlying and well-known deposit of shelly sand and gravel is found near the "Setter Dog" at a level of about 1,200 feet.[4]

[1] I had the pleasure of showing this to several well-known geologists during an excursion of Section C of the British Association—Liverpool meeting, 1896.

[2] See "Geology of the Vale of Clwyd" (McKenny Hughes): Proceedings of Chester Society of Natural Science, No. 3. Also, "Drifts of the Vale of Clwyd": Q.J.G.S. 1887, p. 80.

[3] Mackintosh, Q.J.G.S., vol. xxxviii, p. 184.

[4] Prestwich, R. D. Darbishire, GEOL. MAG. 1865, p. 293.

Tracing the extension of the Low-level Marine Boulder-clays and Sands northwards, we find them typically developed at Blackpool in the well-known cliff section first described by Mr. Binney. They can be seen along the coast of Morecambe Bay by Grange, at Rampside opposite Walney Island, and very greatly developed from Ravenglass to St. Bees Head. All the low-level adjoining country inland is occupied with them, and this marine drift, in which shells can be found, is extensive and widespread.

Turning now to Scotland, we are taught by the very excellent work of Mr. John Smith, of Kilwinning,[1] that a large part of Ayrshire is covered with similar shelly Boulder-clays, and he has traced them up in continuous sections from the sea-level to a height of 1,061 feet at Dippal. These deposits I have myself examined with him, and was much struck by their continuity and regular stratification, no less than with the wonderful preservation of the shell fragments and shells, both often possessing their epidermis unabraded. These beds constitute a really massive formation, often presenting sections 80 feet high through the lateral denudation of the River Ayr. The Boulder-clay in which they are preserved is tough and dry below the weathered surface, so that the shells may by a little trouble be got out of the solid clay; in fact, Mr. Smith informs me that in all his fifty recorded localities he has obtained his specimens in this way. Though rubbed, polished, and striated shells occur in places, the shells as a rule are much better preserved than with us. The boulders in the Drift consist to the greater extent of local rocks of the respective watersheds, mixed with some Highland schists. In the valley of the Girvan Water, Loch Doon, granite blocks up to a large size are common, and they also extend further south.[2]

The area worked by Mr. Smith covers tens of square miles, and I have no doubt that the deposits south of his recorded examples are largely of the same nature. In proof of this I may mention that I discovered shelly Boulder-clay containing Loch Doon granite boulders and striated grits in a small exposure in the banks of Byne Hill Burn, about two miles south of Girvan, and 120 feet above the sea-level. The clay was identical in character with that at Muirkirk which I examined with Mr. Smith, and the shells preserved their epidermis. Mr. J. W. Davies, F.G.S., and I afterwards found fragments of shells at several places in the drift cliffs between Bennan Head and Girvan; also, at a level of 280 feet we found some shell fragments and a small *Turritella* in the drift of Byne Hill Burn, south of the place where the shelly Boulder-clay occurs. This is rather remarkable, as Mr. Smith tells me he has found no *Turritell* in any of his Boulder-clay localities in Ayrshire.

From my observations I am satisfied that here we have an

[1] "On the Discovery of Marine Shells in the Drift Series at High Levels in Ayrshire": British Association, Section C, Liverpool Meeting, 1896.

[2] The Baron's Stone of Killochan is a well-known example, and, according to Geikie, contains 480 cube feet.

area of shelly marine Boulder-clay, with sand and gravel beds of great combined thickness, extending from sea-level to 1,061 feet, with a possible higher development of several hundred feet, and in no sense can these high-level drifts be called "sporadic" deposits. They are one and the same thing with the Low-level Boulder-clay and Sands, with the stratification more highly developed.

These Ayrshire high-level shells have, in the majority of cases, been taken, not from sand and gravel beds, but from the Boulder-clay, and in that respect they are most important and unique. In the first discovered and classical example of Moel Tryfaen the shells are found in sands and gravels at a maximum level of 1,400 feet[1]; at Moel-y-Crio,[2] Flintshire, in sands and gravels at 982 feet; on the range of hills from Minera to Llangollen, first discovered by Mr. Daniel Mackintosh, from 1,000 to 1,200 feet; also in sands and gravels at Gloppa, near Oswestry, at 1,100 to 1,200 feet, described by Mr. Nicholson[3]; in stratified beds of sand and gravel, about 100 feet thick; at the "Setter Dog" before mentioned, near Macclesfield, discovered by Prestwich, also in sands and gravels, at a level of about 1,200 feet. In fact, before Mr. Smith's discoveries in Ayrshire, the whole of the known shelly drifts were classified as High-level Shelly Sands and Gravels.[4] Curiously enough, in the sister island the High-level Shelly Drifts discovered by the Rev. Maxwell Close were in gravelly sand, the preponderating rock being Carboniferous Limestone. Here, however, these drifts can be traced continuously up the valleys from sea-level to their highest development on the Three Rock Mountain.[5]

There are also to be found in many localities shelly drifts at intermediate levels, and sometimes well developed. Dr. Charles Callaway has lately described those of Shropshire, in a paper read before the British Association, Liverpool Meeting,[6] in which he arrives at pretty much the same conclusions with regard to them that I do myself.

Before the Ayrshire deposits were discovered, it seemed somewhat of a mystery why the High-level Shelly Drifts should be so commonly sands and gravels, for these materials are obviously less calculated to preserve the marine calcareous exuviæ than clay. In the case of the Dublin and Wicklow High-level Drifts, this may be accounted for by the enormous quantity of limestone gravel

[1] These deposits have been often visited and described, but the most detailed account of them will be found in the Proceedings of the Liverpool Geological Society, Session 1892–3.

[2] Memoirs of Geol. Survey—Mold, Flint, and Ruthin, p. 139.

[3] Q.J.G.S. 1892.

[4] Marine shells are recorded from Bacup, Lancashire, 800 feet above sea-level, which appear to have come from Boulder-clay.—H. Bolton, Trans. Manchester Geol. Soc., vol. xxi. pp. 574–6. See also Roeder, *ibid.*, 607–19.

[5] "Dublin and Wicklow Shelly Drift": Proc. Liverpool Geol. Soc., Session 1893–4. Mr. Joseph Wright, F.G S., records the occurrence of marine Boulder-clay in Divis, co. Antrim, at between 1,300 and 1,400 feet.—Proc. Belfast Nat. Field Club, 1894–5 (2), iv, pp. 215–6.

[6] "Notes on the Superficial Deposits of North Shropshire": Geol. Magazine, November, 1896, p. 482.

present. The water percolating through this calcareous deposit would no doubt soon get charged with lime, so that the acids would be neutralized and incapable of acting upon the shells. Be this as it may, I observed in many places delicate shells in all stages of decomposition, and so friable that under ordinary subsoil conditions I have no doubt they would have long ago disappeared in solution and left no trace behind. In the deposits at Gloppa and Tryfaen the shells and shell fragments are of a much stronger type, and appear to have become in many cases partially hardened and fossilized, as, indeed, is often the case with our Low-level Boulder-clay shells. On Tryfaen also there formerly existed a protective covering of Boulder-clay lying on the sands and gravels.

The subject I have ventured to deal with in this address is a very wide one; it has been studied by many minds in many countries, and after fifty years of work perhaps there is less theoretical agreement now than there was in the beginning, although I think I see signs that a development of the older ideas is gaining ground.[1] I venture to think that the questions that have arisen, and which will arise in the future, are essentially of a character in which inductive methods are required for their solution. Whichever view is taken, whatever theory propounded, there are many facts known to working geologists which do not range themselves under any one hypothesis. Of late years there has been a tendency to aim at almost mathematical precision in the explanation of laws which are supposed to govern these Ice-Age phenomena. To my mind, the facts which I have been collecting for the last quarter of a century, having seen the whole of the leading examples of High-level Shelly Drifts in Great Britain and Ireland, as well as made a detailed study of the most prominent of them, together with the Low-level Shelly Boulder-clays and Sands over large areas, as also the essentially glacial and land-ice phenomena of the Welsh and Cumbrian Mountains, lead me to think that the precise, deductive, and dogmatic method so much in vogue is ill adapted to evolve truth from these varied and often, apparently, contradictory facts. For my own part I feel that I have gained by my observation and studies a certain little space of sure ground on which to place my lever, but I confess with sorrow that there are many points on which my judgment is less sure than it was in the first few years of study.

Let us first deal with what appears to be the axiom of a certain class of glacialists, for it is interesting to observe that even those who favour the land-ice as opposed to subaqueous theories differ considerably among themselves. This axiom is, that all the shells and shell fragments found in either the Low-level or High-level Drifts are "boulders," that is, they have been removed from their original habitat and carried to the places where they are found, whether at high or low levels, whether on the coast or far inland; furthermore, the carrying agent or pushing agent, as the case may

[1] Professor Bonney has lately given an excellent résumé of the whole subject in his interesting book, "Ice-Work, Present and Past."

be, was land-ice. In proof of this, the fragmentary character of the shells, their worn appearance, and the occasional striæ found upon them, are adduced.

I am far from alleging that the fragmentary character of the shells presents no difficulty, for I distinctly pointed it out in my earlier writings. But do not the opponents of the marine origin of the Shelly Drift, however, make too much of it? Anyone who will take the trouble to examine a gravelly beach at the present day will find a preponderantly large assortment of shell fragments as compared with perfect valves; he will also find them much worn and rounded at the edges, and seldom will he see any epidermis preserved. Dredgings of the sea-bottom also often bring up remains of broken and rounded shells, so that if, in addition to the ordinary agencies of waves and tides shore-ice were introduced, the pounding of this mill would, as Sir Wm. Dawson informs me is at present the case in the St. Lawrence, work destruction even on the living shells.[1]

I have pointed out that in our Low-level Boulder-clays of the north-west of England the fragments as a rule are minute enough to be carried about by marine currents, in which case they may be looked upon as "boulders" without the intervention of land-ice. Perfect valves are, however, found, and *Turritellæ* are very frequently perfect; also small Gasteropods, such as *Trophon truncatus* and *Fusus*, are in perfect preservation. At Gloppa, as Mr. Nicholson's collection shows, there are many very perfect specimens and a wide range of species. I have, however, pointed out again and again that *negative* evidence is pretty sure in the end to prove fallacious. In *Natural Science*[2] (1893) I urged that the High-level Shelly Drifts, so far from being "sporadic" examples, which some had contended, were simply limited by the difficulty of observation, the known sections having only been exposed by artificial excavations, which are not often required in these out-of-the-way localities. I was not, however, prepared for such a tremendous demonstration of the possibility of natural sections exposing shelly drift having been overlooked by geologists as those in Ayrshire appear to have been. It is a striking demonstration of the truth that things that are not expected to be found are not looked for. The striæ on the rocks of Ayrshire work out in a north-westerly direction from Loch Doon, turning more to the westward as they

[1] Since this was written I have had the pleasure of reading Sir Wm. Dawson's "Canadian Ice Age" (Montreal, 1893), which renders clear many phenomena I have observed in Britain on which I could previously only surmise.

[2] The following is the substance of what I said:—"In working out this objection the supporters of the Irish Sea Glacier unconsciously minimise the quantity of High-level Shelly Drift; there is much more in existence than they have persuaded themselves to believe. There is no occasion for me to name the localities over again, as I have stated them at the commencement of this paper. Again, it can hardly be expected that all High-level deposits laid down by the sea should contain shells, and further it is unphilosophical to assume that all High-level drifts have been discovered. Their discovery has generally been in the nature of an accident. I fear the advocates of the Irish Sea Glacier are continually forgetting how difficult it is to prove a negative, and unfortunately the arguments are too frequently of the negative kind."—*Natural Science*, vol. iii, p. 430, 1893.

approach the Clyde.[1] The distribution of Loch Doon granite follows much the same direction; hence it was inferred that the body of the drift travelled outwards from the land and consequently could not be sea-borne.[2] This, together with the very few recorded examples of shelly drift in the South of Scotland, the highest being that of Airdrie,[3] and the previously expressed opinions that the Scotch "Till" was the result of land-ice stifled observation.[4] It was only by the acumen and industry of Mr. John Smith, of Kilwinning, within the last year that these enormous stratified beds at levels up to 1,061 feet have been proved to contain in the Boulder-clay beds, shells often well preserved with the epidermis intact: a discovery of the utmost importance, to be welcomed as throwing much light upon some obscure points.

We naturally ask ourselves why are the High-level shelly beds in Ayrshire constituted of Boulder-clay, while those of England, Wales, and Ireland are of sand and gravel? After carefully examining all the leading examples, the natural explanation that presents itself to me is a very simple one, viz. the form of the ground where they occur.

In England and Wales the High-level Shelly Drifts are on the summits of hills or ranges where there is either little material for the manufacture of clay, or the orographic position renders it unsuitable for the deposition of fine muds. In Ireland the presence of limestone gravel in large volumes tells the same story, but in Ayrshire the High-level Shelly Boulder-clays near Muirkirk occur in a wide embayment or plateau, surrounded by higher land in which the deposit of fine material derived largely from the Carboniferous rocks might readily take place. There are together with local rocks Highland schists found in the Drift, and these may most readily be accounted for by floating-ice. The very considerable difficulty in assenting to the necessary convolutions and diverse tracks of an ice-sheet or sheets, varied in direction and volume from time to time to

[1] See Memoirs of the Geological Survey of Scotland, Explanation of Sheet 7, p. 14.

[2] In the "Scenery of Scotland" (second edition), by Sir A. Geikie, a Drift map is published in which the only shelly drift shown between the Clyde and the Irish Sea is in the extreme south-west corner of Scotland. It is evident from this that the important shelly drifts of Ayrshire were unknown at the time of publication.

[3] Mr. Dugald Bell, previous to the discoveries of Mr. Smith in Ayrshire, threw such doubts upon the recorded instances of the occurrence of shells in the Drift of the South of Scotland that the stock example of Chapelhall, near Airdrie, which was supposed to prove a submergence of about 500 feet, was omitted in the last edition of Dr. James Geikie's well-known "Ice Age." A committee with Mr. Dugald Bell as a member re-examined the locality, with a result entirely *negative*. This is only another instance of the futility of *negative* evidence, for, as we see, not long afterwards evidence of the most conclusive sort of the presence of sea-shells in natural sections open to the world were found in Ayrshire up to double the height. See "The Great Ice Age and Submergence," by Dugald Bell, GEOL. MAG., Dec. IV, Vol II, p. 322.

[4] In a paper read before the Geological Society of Glasgow, April, 1880, and published in its Transactions, vol. vi, pt. 2, pp. 264–276, I stated my opinion that the Scotch Till and the Low-level Marine Boulder-clay of Lancashire are continuous, and that some of the unfossiliferous Scotch Till had probably been formed under glaciers where they debouched into the sea. This is rendered far more probable now that we know that the mud of the Scotch Boulder-clay is marine.

meet the exigencies of the latest discoveries, are immeasurably increased when we attempt to explain these Muirkirk shelly deposits on that system. The great bulk of materials enclosed in the Drift of Ayrshire has worked outwards and downwards, as might be expected in a world governed by gravitation. This, I conceive, is the true explanation, taken together with the wider area on which denuding agents could work, of the presence of Boulder-clay covering the country in large sheets at low levels.

Those who from their studies of glacial phenomena have been led to look upon land-ice as the almost exclusive agent in the manufacture and distribution of glacial deposits, ask those who are in favour of the sea origin of a large portion of these deposits to point out in all beds classed as marine, marine exuviæ, and if they cannot do so, consider it fatal to the submergence theory.

Is not this an extravagant demand to make, for it is really only under exceptional conditions that such organic remains are preserved? Destruction was everywhere going on from the time of the existence of these molluscs in the icy and stone-laden seas to that in which they have been exposed to destruction and dissolution by percolating acidulated waters when these beds became exposed to subaerial influences. We have seen that where the matrix in which these organic remains are entombed is of a non-porous and dry character, like much of the Boulder-clay of Ayrshire, the remains are preserved even to the epidermis. There is also the example of Clava in Nairn, which the Committee of the British Association appointed to investigate pronounced to be a shell-bed *in sitû*, resting upon 36 feet of coarse gravel and sand, and overlaid by 63 feet of Boulder-clay and sands, showing a submergence of the land to the extent of 500 feet.

Again, if we look broadly at the distribution of these shelly deposits, we find that they occur all round our maritime coasts in Lancashire, Cheshire, and Wales, in Cumberland and Westmoreland, Wigtownshire and Ayrshire, and along the eastern coasts of Ireland. The same is to be said of the eastern coasts of England and Scotland. Is it probable that land-ice would so universally work from the sea towards the land? Are we to explain the presence of sea-shells imbedded in Boulder-clay up to 1,061 feet in Ayrshire, 25 miles distant from the coast in a bee-line, by a great glacier proceeding from the Atlantic, crossing Cantire and the Firth of Clyde, and working 25 miles inland, when the travel of the material, excepting as regards some Highland schists, has been in the opposite direction?[1] I confess that my education in the principles of Hutton and Lyell, and my own natural mode of thought, make me averse to such drafts upon our scientific imagination, when there is a simple and direct explanation close at hand. It was well observed by Playfair, some 90 years ago, that "a theory that explains everything explains nothing."[2] May we not

[1] See Memoir of Geol. Survey, Scotland, Explanation of Sheet 7.
[2] "Illustrations of the Huttonian Theory."

apply this excellent saying to the exaggerated form in which land-ice theories are often presented to us?

The phenomena of the Glacial Period in Britain contain some of the most interesting problems it has yet been the lot of geologists to attempt to solve. It therefore behoves us to approach the subject in a spirit of humility. That such varied explanations have been proffered from time to time, that most contradictory conclusions should be drawn from well-ascertained and generally acknowledged facts, is curious and somewhat depressing. There is, however, this reflection to comfort us: however strange, however contradictory, however devoid of common-sense the various explanations and theories of the Glacial Period appear to the various observers and reasoners upon them, the total effect is, like that of the hypothetical Ice-Sheet, a push forward. Without opposition, observation stagnates, so that the first effect of enthusiasm, even if directed in lines that afterwards prove to be mistaken, is to advance the science we love so well. Even if a theory be utterly false, it may prove of great educational value, for, until every possible line of reasoning has been traversed, secure ground cannot be reached.

IV.—On Quartzite Lenticles in the Schists of South-Eastern Anglesey.[1]

By Edward Greenly, F.G.S.

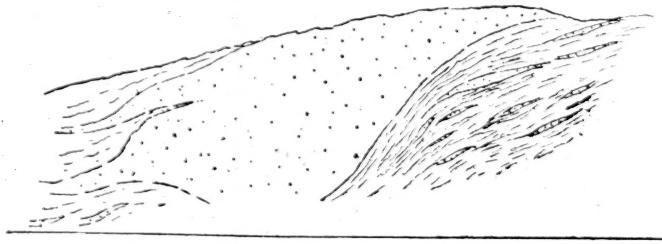
THE prevailing type of schist in the south-east of Anglesey, for some miles to the north and north-west of Beaumaris, is a wavily foliated, pale-green, chloritic rock,[2] the quartz in which, though more abundant than appears at first glance, is in a very fine state of subdivision. In a common variety, especially prevalent about Llanddona, quartz forms nearly the whole of the rock, but it is still in very compact seams, separated by partings of chlorite or mica.

In none of these rock-types can original clastic grains be detected by the naked eye or with the hand-lens; but areas occur in which they contain great numbers of lenticles of quartz, imbedded in a finely foliated matrix of much finer quartz and chlorite. Many of these lenticles have the aspect and fracture of vein-quartz; but a large number, and in some areas almost all, are fragments of true granular quartzite, composed of clastic grains often well rounded. The whole rock, indeed, might be termed a "quartzite-augen-gneiss." With a few exceptions, these fragments range in size from a quarter of an inch to three feet across, but they are apt to be elongated, the axes being often as 8 : 2 : 1. Very frequently they are ellipsoidal rather than lenticular, the bounding curves being continuous all round.

[1] An abstract of this paper was read before the British Association, Liverpool, September, 1896.

[2] There are other green schists in the same area, which are probably of igneous or pyroclastic origin.

Round about them the foliated matrix sweeps in graceful curves, its folia being sometimes truncated against the sides of the lenticle at a low angle. There is abundant quartz-veining within the body of the quartzite, locally obliterating the original clastic texture; and near the margin the quartz-grains are apt to be flattened, a faintly schistose texture being set up in the mass.



Lenticle of quartzite, 3½ feet in length, in pale-green schist, containing many small lenticles. Llansadwrn.

Viewed as a whole, the structures reminded me strongly of those in the mylonites at the Moine thrust in the North-West Highlands of Scotland, except that the lenticular fragments in the latter are generally (so far as I have myself seen) portions of coarse felspathic, gneissoid, or granitoid rocks. But a mylonite, in which the fragments were of rather coarse gritty sediment, would, if a certain degree of crystallization were set up in the matrix, be indistinguishable from these schists.

On reading the paper by my old colleague Mr. Lamplugh (Q.J.G.S., vol. li, 1895) on the "Crush-Conglomerates" of the Isle of Man, it appeared to me that these might yield further light still upon the subject. By his kindness I have been able to study the Manx phenomena in several of the most typical localities, and I have but little doubt that these East Anglesey schists are essentially "crush-conglomerates" whose matrix (containing originally a good deal of iron and magnesia) has become crystalline.[1] Even in the rounding and elongation of the fragments they resemble the crush-rocks of Ramsey and Sulby Glen.[2]

In the district at present mapped, I have failed to trace these rocks into any unbroken sedimentary series. But that the lenticles are of truly cataclastic origin, and not sheared and flattened boulders in a now schistose conglomerate, is, I think, practically certain, from the occurrence among them of four masses of much larger size. These are the quartz-rocks of Pen-y-parc, near Beaumaris, which

[1] An explanation, practically the same, was applied by Sir A. Geikie and Mr. Peach to some rocks of doubtful age in the neighbourhood of Llangefni, Anglesey. (Geikie, Pres. Address Geol. Soc. 1891, p. 130.)

[2] I have since seen the breaking up of a banded slate into rounded fragments on a small scale, though very markedly, at Llyn Padarn, Llanberis. Mr. Lamplugh, however, lays stress, and I think justly, not so much on the bare occurrence of the phenomenon as on its great scale and extent, in the Isle of Man.

have been described by Professor Bonney and the Rev. J. F. Blake. The mass which has been quarried is a lenticle of which about 175 × 75 ft. are clearly exposed. Its truly sedimentary character has been described by Professor Bonney. Its greatest length is probably not less than 700 ft.; and there are in addition three smaller lenticles a little further east, whose longer axes are from 100 to 200 ft.

These great masses of quartzite can only have been portions of a once continuous bed or beds,[1] from which they have been torn out and carried away, as have been the innumerable masses of the Cambrian quartzites in the North-West Highlands, of somewhat similar form, which are piled up on the minor thrust-planes of that region. Judging also from what we see in the Isle of Man, these beds were probably the more massive members of an alternating series of grits and shales, the thin and flaggy bands of grit having furnished the material of the smaller lenticles.

The complexity of structure consequent upon such movements is admirably illustrated by the two regions just quoted; especially where, as in the Isle of Man, movement has recurred at a later period, superinducing new structures, and to some extent effacing the records of the earlier episodes.

To what extent this may have happened in Anglesey it is at present impossible to say; but it seems probable that the movements which have affected the schistose rocks of that island were of a very high degree of intensity; and the structural relations of the rock-masses may therefore be expected to be in a corresponding degree complex and deceptive.

V.—On the Exmoor Earthquake of January 23, 1894, and on its Relation to the Northern Boundary Fault of the Morte Slates.

By Charles Davison, Sc.D., F.G.S.;

King Edward's High School, Birmingham.

A SLIGHT earthquake of intensity IV, according to the Rossi-Forel scale, was felt in and near Exmoor at about 9 a.m. on January 23, 1894. Its interest lies, not so much in the seismic phenomena presented by it, as in its connection with the northern boundary fault of the Morte Slates.

In studying this earthquake, I have been able to avail myself of 56 records from 48 different places, as well as of 13 other records from 13 places where, so far as known, it was not perceived. The names of the observers and others to whom I am indebted for

[1] The appearances of irregular or intrusive junction figured by Professor Blake are deceptive, being due to the form of the present outcrop. Such discordance as exists is not more than that which sometimes occurs at the margins of smaller lenticles, and may be expected in any highly disturbed region. The relations of this mass of quartzite do not, I think, necessitate our referring its origin to causes acting locally or sporadically.

information are given below,[1] but my thanks are specially due to the Rev. W. Hook of Porlock, Mr. A. L. Ford of Lynton, and Mr. J. H. Barrow of Challacombe, for several additional records which they were kind enough to send me.

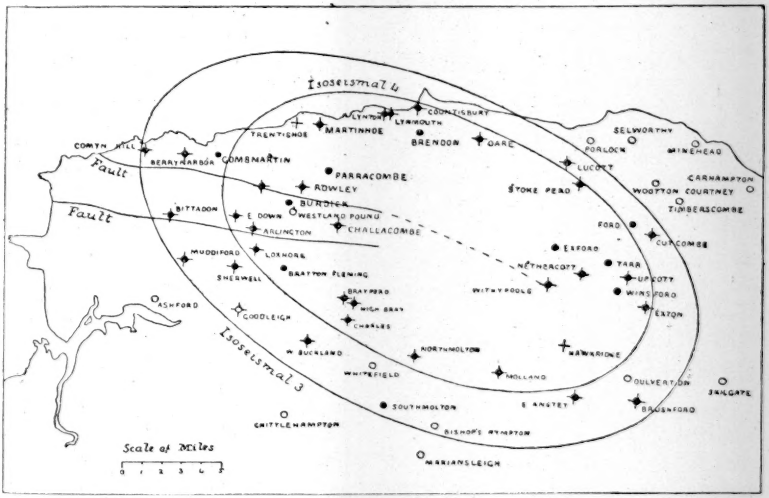
It is possible that there may have been two preparatory shocks. I have only received one record of each, and, in accordance with the usual rule, their occurrence should not be regarded as quite certain, though they are probably of seismic origin: (1) January 22, about 10 p.m., at Arlington, a slight shock, with a noise like underground thunder; (2) January 23, about 8.40 a.m., at Berrynarbor, a series of small waves, duration one second, intensity III, preceded slightly and accompanied by a noise like that of a heavy cart rumbling by, the shock and noise being less intense than those of the principal earthquake at 9 a.m. Both places lie near the north-west end of the disturbed area of the latter, Arlington being close to the southern boundary fault of the Morte Slates, and Berrynarbor about half a mile north of the northern fault.

Nature of the Earthquake.—Detailed accounts of the shock are few in number, and, as will be seen from the map, observations of any kind are wanting in the epicentral district. As a rule, the shock consisted of a tremulous motion, which gradually increased in intensity and then died away. This was the case even at Berrynarbor and Brushford, which are near opposite ends of the disturbed area. At East Anstey, the shock began with a tremulous motion for about three seconds, after which came two prominent vibrations, and then a series of gradually decreasing vibrations for about four seconds. From Eastdowne there comes a somewhat similar observation, a tremulous motion gradually increasing in intensity and then as gradually dying away, and in the middle two distinct

[1] Authorities.—Arlington, Rev. T. de L. Sprye; Ashford, Mr. H. C. Fletcher; Berrynarbor, Rev. R. Churchill; Bishop's Nympton, Rev. E. A. Lester; Bittadon, Rev. E. Braund; Bratton Fleming, Mr. J. H. Barrow; Brayford, Mr. J. Carter; Brendon, Mr. A. L. Ford; Brushford, Rev. C. S. Barber; Burdick, Mr. W. R. Smyth; Carhampton, Rev. W. P. Michell; Challacombe, Mr. J. H. Barrow, Mr. J. Carter; Charles, Mr. J. Carter; Chittlehampton, Mr. H. E. Seymour; Combmartin, Rev. H. C. Jenoure; Comyn Hill, Miss M. Slesser, Mr. J. G. Wood; Countisbury, Rev. H. F. Ramsay; Cutcombe, Rev. J. J. Large; Dulverton, Rev. R. J. Collyns; East Anstey, Rev. J. Owen; Eastdowne, Rev. R. H. Giles; Exford, Mr. A. L. Ford, Rev. J. J. Large, Rev. J. Owen; Exton, Rev. F. K. Warren; Ford, Rev. E. P. Stanley; Goodleigh, Mr. G. Mugford; Hawkridge, Mrs. Thomas; High Bray, Mr. J. Carter, Rev. C. P. Whitaker; Kentisbury, Rev. H. C. Jenoure; Loxhore, Rev. G. O. Ramsay; Lucott, Rev. W. Hook; Lynmouth, Mr. E. B. Jeune; Lynton, Rev. W. E. Cox, Mr. A. L. Ford; Mariansleigh, Rev. A. Winnitrith; Martinhoe, Rev. R. W. Oldham; Minehead, Rev. A. H. Luttrell; Molland, Mr. S. J. Case; Muddiford, Mr. T. R. de Suerin; Nethercott, Rev. W. P. Anderson; Northmolton, Dr. Spicer, Rev. A. Winnitrith; Oare, Rev. H. F. Ramsay; Parracombe, Mr. J. H. Barrow; Porlock, Rev. W. Hook; Selworthy, Rev. F. Hancock; Skilgate, Rev. C. A. B. Harris; Southmolton, Mr. J. H. Barrow, Mr. A. L. Ford, Rev. J. Owen; Stoke Pero, Rev. W. Hook; Tarr, Rev. W. P. Anderson; Timberscombe, Rev. R. J. Crosswell; Trentishoe, Mr. J. H. Barrow; Upcott, Rev. W. P. Anderson, Mr. Tapp; West Buckland, Dr. Spicer; Westlandpound, Mr. W. R. Smyth; Winsford, Rev. W. P. Anderson, Rev. J. J. Large, Mr. A. Tudhall; Withypool, Mr. A. Tudhall; Wootton Courtenay, Mr. E. Brazier.

instantaneous bumps; a sound, as of a heavy cart-load of iron crossing a wooden floor, grew and died away with the trembling, encountering, as it were, two large stones on the way at the instants when the bumps were felt. At Challacombe two distinct rumbles were heard by one observer, without any interval between, each increasing in intensity and then dying away, the first and louder lasting three or four seconds, the second rather less. Lastly, at Molland two rumbles (like distant thunder or firing of artillery) were heard, but in this case there was an interval of a few seconds between them, and it was during this interval that the only perceptible movement was felt.

Disturbed Area and Isoseismal Lines.—The two curves on the map represent the isoseismals of intensities IV and III respectively, the latter forming the boundary of the disturbed area. The isoseismal III is $29\frac{3}{4}$ miles long, $16\frac{1}{2}$ miles broad, and contains 389 square miles. The length of the isoseismal IV is $22\frac{3}{4}$ miles, its breadth $12\frac{1}{4}$ miles, and the area included within it 228 square miles. Both curves are elongated ellipses, and their longer axes are parallel, being directed W. 22° N. and E. 22° S. If the earthquake were due to fault-slipping, this must, therefore, be the direction of the fault-line in the neighbourhood of the epicentre.



Map of the Exmoor Earthquake of Jan. 23, 1894.[1]

The distance between the two isoseismals being $1\frac{1}{4}$ miles on the north side of the longer axis, and 3 miles on the south, it follows

[1] The places where the shock was felt are shown by small black discs; a cross drawn through the disc means that the sound was also heard; a cross alone, that the sound was heard, no reference in the account being made to any perceptible vibration; a small circle marks the places where the earthquake was not observed; and a cross drawn through a circle, a place where the sound was heard, but no shock was felt.

that the originating fault must hade to the south. Moreover, the centre of the isoseismal IV lying half a mile south-west of Simonsbath (or about $5\frac{3}{4}$ miles west of Exford), the fault-line must pass a little to the north of this point, and thus its position is approximately determined.

Origin of the Earthquake.—The geology of the district has been studied recently by Dr. Hicks, though the complete results of his work are not yet published.[1] On the map are shown by continuous lines the north and south boundaries of the Morte Slates, so far as they are given in the papers referred to. The discovery of organic remains in these slates has led Dr. Hicks to regard them as the oldest rocks of the district, the fossils in some of the beds indicating "an horizon low down in the Silurian (Upper Silurian of Survey)," while the rocks on either side, though belonging to varying horizons, are assigned by him to the Devonian period. "A great thrust fault extends continuously along the northern boundary of the Morte Slates, from the coast near Ilfracombe to the Exe Valley. On the south side there is evidence generally also of a well-marked fault." Both the faults hade towards the south.

Unfortunately, Dr. Hicks' map does not show the course of these faults more than about two miles east of Challacombe, so that they stop short of the epicentral area of the Exmoor earthquake. It is evident, however, from its final trend, that the northern boundary fault occupies very nearly the position required by the seismic evidence. The dotted line on the earthquake map is drawn so as to continue the line of fault in a direction parallel to the axis of the disturbed area, and the true position of the fault-line will, I believe, be found to be either along this line or, more probably, a little to the north of it.

If the two preliminary tremors referred to above were of seismic origin, the first movement seems to have been a slip along the southern boundary fault in the neighbourhood of Arlington. This was apparently followed, after less than eleven hours, by a slip along the northern fault, somewhere near Berrynarbor, and about twenty minutes later by the more marked but interrupted slip which gave rise to the double series of vibrations of the earthquake here described. That the length of fault over which the latter slip occurred was considerable, is evident from the form and dimensions of the isoseismal lines; possibly it may have been as much as nine or ten miles. Whether the rocks on the north or south side of the fault were displaced, is not quite clear; but, if we may rely on the evidence of the two preparatory shocks, the more probable alternative is, that the Morte Slates over a length of several miles were forced bodily forward along the thrust-plane.

[1] "On the Morte Slates, and Associated Beds, in North Devon and West Somerset," Part I: Quart. Journ. Geol. Soc., lii, 1896, pp. 254 72. "The Palæozoic Rocks of West Somerset and North Devon": Proc. Geol. Assoc., xiv, 1896, pp. 257–70.

NOTICES OF MEMOIRS

Explanation of the Plan adopted for Preparing an "Index Generum et Specierum Animalium." By C. Davies Sherborn, F.Z.S.[1]

THE following description of the work of preparing an Index to the generic and specific names of animals, both recent and fossil, which was commenced by the author in July, 1890, has been prepared for the Society, at the request of Sir William Flower, Mr. Sclater, and Dr. Henry Woodward.

The difficulty of finding accurate and reliable lists of the species of any particular genus was pointed out by Darwin years ago, and impressed itself so strongly on that naturalist that he personally endowed the undertaking which we know as the "Index Kewensis," recently brought to so successful a conclusion by Benjamin Daydon Jackson. In this book of reference there are some 600,000 generic and specific names of flowering plants. The botanist has now a key to the literature of Phanerogams for 150 years within covers, and all difficulty in keeping pace with present and future descriptions of new phanerogamic plants has been removed.

It is quite otherwise with zoological generic and specific names. Agassiz, Marshall, Scudder, and others have partially catalogued the genera; Waterhouse has listed the genera of birds; H. G. Bronn, John Morris, and, more recently, R. Etheridge, have provided lists of fossil species. But no one book including references to all names that have been given to fossil and recent animals has yet been attempted. The vastness of the record is appalling, but given time all difficulties disappear.

The work now commenced by the German Zoological Society, which was described before this Society at a recent meeting, and known as "Das Tierreich," will be familiar to all present; and it has been suggested that a brief account of the "Index Generum et Specierum Animalium" should be put on record in the same manner.

In May, 1890, a letter appeared in *Nature* and in *La Feuille des Jeunes Naturalistes*, from the author, setting forth a scheme for the compilation of such a work, and inviting suggestions for improved details or other matter. Beyond friends interested at the British Museum, those who offered valuable suggestions were David Sharp, Alfred Newton, Sven Lovén, and Victor Carus. It was, therefore, obvious that the details were satisfactory to those interested, and work was commenced on July 1, 1890.

Since that date recording has steadily progressed (circumstances have restricted the time at disposal to an amount equivalent to three years), and a total of 130,000 slips have been stored away in the alphabetical order of genera. Notices of the progress of the work have appeared in *Nature*, vol. xliv, p. 207 (1891), and *Natural Science*, vol. iii, p. 379 (1893), and the manuscript has frequently

[1] Proceedings Zool. Society, 1896, p. 610.

been referred to by those in need of information at the British Museum and elsewhere.

The following is a reprint of the original set of rules :—

(1) The earliest reference is to date from the twelfth edition of Linnæus, 1766.

(2) The last reference to close with December 31, 1899.

(3) The names of genera and species to be given in one alphabetical sequence, and accompanied by a reference to the original source.

(4) The names of species of each genus to be also quoted in alphabetical order under that genus.

(5) No attempt at synonymy to be given ; but, to assist reference, the various genera in which a species has from time to time been placed to be indicated under that species.

(6) Pre-Linnæan names to be quoted as founded by the author first using them after 1766 : e.g. *Echinocorys*, Leske, 1778 (*ex* Klein, 1734). Should a pre-Linnæan species or genus have been renamed after 1766, before the post-Linnæan use of that pre-Linnæan name, the new name is to stand. [References will be given to Artedi, Brisson, and Scopoli, in accordance with British Association rules.]

As soon as the work commenced it was found advisable to adopt the tenth edition of the "Systema" as a starting-point, instead of the twelfth. The reasons for this adoption need not be discussed here; the use of the tenth edition is fast becoming universal. This alteration caused a slight modification of several of the proposed rules. At the same time a reference is also given to the twelfth edition of the "Systema," as it will be convenient to many people and will not increase the number of slips in any appreciable degree.

Each genus-name and each species-name is recorded on a separate slip, the original reference being quoted ; and every time a species-name is transferred to a new genus a separate slip is used, the quotation including a reference back to the original genus in which the species was first placed.

Each slip is made out in duplicate—one set being sorted up in alphabetical order of genera ; and a second set being kept tied up as an index of the contents of the particular book quoted.

References are taken from one book at a time—*i.e.* a book is gone through from cover to cover—every genus and species, and every change of genus, being systematically recorded ; thus completely disposing of that particular book, and ensuring the almost absolute certainty of every reference being taken. This system proves far more exact than the recording of any special group of animals at one time. It further permits of the printing from type of a reference to that particular book on each slip, and thus ensures the absolute accuracy of the reference with the sole exception of the page. The entries are made in black-lead pencil and black or blue carbon paper —both methods having proved to be quite indelible.

A particular paper has been chosen, known as "white rope," which presents the requisite stiffness for an edge-on arrangement

of slips, the toughness necessary for constant handling, a surface equally convenient for pencil and carbon paper, and a cheapness of 1*s.* 2*d.* per 1000 slips. The size of slip employed is 127 × 63 mm. (5 × 2½ inches).

Nomina nuda are distinguished by the letters [*n. n.*].

Nomina nuda accompanied by figures by the letters [*n. et f.*].

In those cases where an author has described and figured a species some time after printing his *nomen nudum*, a reference is also given to the *nomen nudum*, when possible.

Particular attention has been paid to the date of publication of books, periodicals, and serials. This is a part of the work which demands considerable time and patience, but the results obtained fully justify the labour. The more important results as to dates already arrived at and published are:—

Pallas, P. S., Icones Insect. (See Annals Mag., ser. 6, vii, p. 236, 1891.)

Pallas, P. S., Nov. spec. Glir. (See Annals Mag., ser. 6, vii, p. 236, 1891.)

Schreber, J. C. D., Säugthiere. (See Proc. Zool. Soc. 1891, p. 587.)

Sowerby, Genera Recent Shells. (See Annals Mag., ser. 6, xiii, p. 370; 1894.)

Encyclopédie Méthodique. (See Proc. Zool. Soc. 1893, p. 582.)

Jardine and Selby, Illustr. Ornith. (See Ibis, 1894, p. 326.)

Moore, F., Lepidopt. Indica. (See Annals Mag., ser. 6, xi, 1893, p. 260, and ser. 6, xiv, 1894, p. 464.)

Siebold, P. F. von, Fauna Japonica. (See Proc. Zool. Soc. 1895, p. 149.)

The date of publication of a species is taken to be that date on which the print in which the name appears is offered for public sale or public distribution.

No author's copy, and no excerpt from any publication distributed privately before such publication is offered for public sale or public distribution, have been accepted.

In the case of privately printed books, entries taken from them are distinguished by the words [*auct. typ.*].

In all cases where the date is doubtful and cannot be definitely ascertained, the date figures are enclosed in brackets [ ], or have some other distinguishing mark—*e.g.* (?)—placed against them.

In the case of plates appearing before the text, the date of each is given if ascertainable (*e.g.* Schreber's "Säugthiere"), but in no case is the date of a plate accepted in preference to the date of text, for the reasons which follow:—

The figure depicted on a plate may, or may not, be the drawing intended by the author; it is the work of the artist, who is also responsible for the descriptive legend. In numerous instances the descriptive legend on a plate is quite erroneous, and has been repudiated by the author in his text. Until the text descriptive of a plate appears, the names on the plate must be considered as *nomina nuda*, and it is open to anyone to describe and rename such *nomina nuda*.

Species "indett.," if figured, are included in the Index.

Misprints are quoted only if considered liable to cause confusion.

The following is an example of the Index as proposed to be carried out. The inclusion of an alphabetical list of species under each genus-name is a matter for consideration, if ever the MS. comes to the printing-office. It can be adopted or rejected at option, and if adopted the duplicate set of slips will be available for the purpose.

In arranging the Index for printing it is proposed to print one alphabetical list from beginning to end; the species-names and the genus-names falling into one order according to the arrangement of their spelling. The following are the reasons for arranging the work under species and not under genera, as in the "Index Kewensis":—

1. No synonymy of species is attempted: that depends on the idiosyncrasy of the systematist.
2. Any attempt at specific synonymy would be fatal to progress, as experience shows that vast changes may take place in a single year.
3. An arrangement under species permits of a generic synonymy, for by running the eye down the second column of the printed work, it will be possible to ascertain the various generic names with which a particular species-name has been connected.

Acervulina, *M. Schultze, Org. Polyth.* 67. Rh. 1854.
[acinosa; cretæ; globulosa; inhærens.]
acinosa Acervulina, *M. Schultze, Org. Polyth.* 1854, 67.
acuta Alveolina, *Sacc & Meneghini, Cons. geol. Tosc.* 1851, 206.
Alveolina, *A. D. D'Orbigny, Ann. Sci. Nat.*, vii, 306. Rh. 1826.
[acuta; boscii; bulloides; compressa; costulata; cylindrica; decipiens; depressa; ellipsoidalis; elliptica; elongata; eximia; fortisii; etc.]
Archiacina, *Munier-Chalmas, B. S. géol. Fr.* [3], vii, 445. Rh. 1879.
[armorica; munieri.]
armorica Archiacina (D'Arch.), *Munier-Chalmas, B. S. géol. Fr.* [3], vii, 1879, 445. [Cyclolina.]
—— Cyclolina, *D'Archiac, B. S. géol. Fr.* [2], xxv, 1868, 376.
Cyclolina, *A. D. D'Orbigny, Foram. Vien.* 139. Rh. 1846.
[armorica; carinata; cretacea; dutrenoyi; impressa; pedunculata; præalta.]

The group and date of the genus are shown by the "Rh. 1854" = Rhizopoda, 1854.

From this description of the "Index Generum et Specierum Animalium," it will be seen that a manuscript comprising 130,000 references is already in existence and is available for daily reference.

Sir William Flower, Dr. Günther, and Dr. Woodward took so much interest in the original scheme that they at once offered the necessary space and cabinets for the storage of the manuscript at the British Museum (Natural History)—an offer of considerable value, as it not only renders the MS. easily accessible to those wishing to consult it, but ensures safety from fire and other destructive agencies. The General Committee of the British Association have been generous enough to assist the work by a donation of £70. This has been of considerable assistance in the purchase of paper, material, etc.

A manuscript of this nature is necessarily imperfect for any one genus until the whole literature has been gone through. As far as possible it is compiled from 1758 upwards, but often a side issue takes the compiler on even into the present year. Every book when completed is ticked off in some well-known Catalogue, and a catalogue slip is made, so as to allow of an alphabetical register.

It is believed that the plan adopted for preparing an "Index Generum et Specierum Animalium" is so arranged and so carried out that the work is completed day by day so far as it goes, and that it would be easy for any individual to continue the carrying out of the scheme to-morrow should there be occasion to do so.

REVIEWS.

I.—Geological Survey of Scotland. Explanation of Sheet 75 of the Geological Survey Map—including West Aberdeenshire, Banffshire, parts of Elgin and Inverness. By Lionel W. Hinxman, B.A.; with Petrological Notes by J. J. H. Teall, M.A., F.R.S. 8vo, pp. 48. Price 1*s.* 6*d.* (Edinburgh: Printed for H.M. Stationery Office, 1896.)

THE area described in this memoir is a mountainous one. A small portion of the Spey Valley lies to the north-west by Cromdale, and a group of metamorphic rocks developed in and around the Haughs of Cromdale and the Braes of Abernethy is noted as the "Cromdale Hills Series." The rocks represent a set of alternating shales and sandstones which have been converted into micaceous and siliceous schists and flagstones. They are thoroughly granulitized, and their sedimentary origin is only occasionally to be recognized in the dark laminæ, which under the microscope are found to be composed of heavy residues such as ilmenite and zircon. In addition to the granulitization, the original mineral particles are drawn out in one determinate direction, giving a striped appearance to the rock in many places that at once catches the eye.

The central portion of the area, east of Glens Lochy and Loin, is occupied by metamorphic rocks grouped as the "Banffshire Series," which includes quartzite (showing in places "rod-" and "mullion-structure"), black schists, mica-schists, slates, and limestone. The original bedding-planes in the limestone are generally recognizable, but the rocks are often intensely crumpled and folded, while additional planes of schistosity have been developed in several places. Overlying these old rocks there are, as at Tomintoul, outliers of Lower Old Red Sandstone. At Carn Meadhonach there is upwards of 500 feet of conglomerate belonging to this formation. No organic remains have yet been discovered in the Old Red strata, which include sandstones as well as breccia and conglomerate. Various glacial phenomena are described, and there are notes on peat and alluvium.

The igneous rocks include portions of the granite-mass of Cairngorm on the south of the area, and large tracts of diorite, epidiorite, and hornblende-schist in the eastern portion of the area, at Kirkton of Glenbucket, etc. Serpentine also occurs.

Among the economic products, building- and paving-stone is obtained from the Old Red Sandstone, and lime for agricultural purposes from the limestone. Iron-ore has been smelted at Nethy Bridge, and manganese-ore was formerly obtained. Diatomite occurs in places, and veins of plumbago have been met with. A few mineral wells are recorded.

In his petrographical notes, Mr. Teall notes the occurrence of zircon, rutile, and ilmenite in the rocks of the Cromdale Hills; and he calls attention to the abundance of cordierite in the metamorphic rocks. Interesting particulars are given of the structure of both metamorphic and igneous rocks.

The absence of a small index to this work is to be regretted, and it should be mentioned that the type is not so clear nor the paper so good as in the previously published explanation of Sheet 5.

II.—Elementary Geology. By G. S. Boulger, F.L.S., F.G.S., Professor of Geology, City of London College. Small 8vo, 180 pages, with woodcuts. Price 1*s.* 6*d.* (Collins and Co.: London and Glasgow. Not dated.)

THIS is a revised edition of the late Dr. W. S. Davis's little introductory handbook of Geology. The principles of Geology, and their illustration by reference to main facts concerning the past and present conditions of the earth, are systematically and successively stated in twenty short chapters, concisely written, and illustrated with the woodcuts usually met with in such geological handbooks.

The author avoids, to a great extent, entering into disputed and hypothetical explanations of natural facts. He is clear in his statements, though brief; and has evidently the experience of a sound and practical teacher.

The plan of the book is good for a young earnest geologist, who, seeking for visual evidences, in quarries and cliffs, as well as in museums, will take the successive chapters as leaders for his notebook and method of study. For amateurs this little book of elements can be recommended as opening a way of beginning to learn the subject systematically.

The author has especially in view the aid that can be given to candidates in geological examinations, and he reprints the questions given in "Science and Art" examinations in 1889–96, and 183 questions taken from other sources, with references to the correlative paragraphs in the book.

A good Index completes this well-printed and recommendable little handbook.

REPORTS AND PROCEEDINGS.

Geological Society of London.

November 4, 1896. — Dr. Henry Hicks, F.R.S., President, in the Chair.

The President referred to the loss which the Society had sustained by the decease of Professor A. H. Green, M.A., F.R.S., who had served for some years on the Council, and was Vice-President at the time of his death. His wide knowledge of science, his perfect uprightness of character, and his genial good-nature were greatly valued by all those who had the privilege of coming into contact with him.

The President further announced that the Council had that afternoon passed the following resolution :—

> "The Council of the Geological Society are deeply sensible of the loss which they have sustained in the death of Professor Green, M.A., F.R.S., one of their Members, and a Vice-President of the Society. In placing on record their acknowledgment of the services which he has often rendered to the Society, they desire to express their heartfelt sympathy with Mrs. Green and the family in their sudden bereavement."

The President announced that Lady Prestwich, in fulfilment of the terms of a bequest of her late husband, had offered to the Society 260 bound volumes of geological tracts from his Library. Also, that a sum of £800 had been bequeathed to the Society by Sir Joseph Prestwich, the interest to be applied to the triennial award of a medal and fund: this bequest to take effect subsequent to the decease of Lady Prestwich.

The Secretary announced that the Rev. P. B. Brodie, M.A., F.G.S., had presented to the Society a framed platinotype portrait of himself; that Capt. G. E. A. Ross, F.G.S., had presented eight lithographic portraits of distinguished geologists; and that Miss Hawkins had presented a portrait of her late father, Waterhouse Hawkins, Esq.

The following communications were read :—

1. "Additional Note on the Sections near the Summit of the Furka Pass (Switzerland)." By T. G. Bonney, D.Sc., LL.D., F.R.S., V.P.G.S., Professor of Geology in University College, London.

The author, during a visit to Switzerland in 1895, had taken the opportunity of completing the examination of the sections on the western side of the Furka Pass, and of glancing again at those previously studied. The white, sometimes slightly quartzose or micaceous marble which, as already described, crosses the summit of the Pass, descends towards the west, but forms a cliff for some little distance by the roadside until it is crossed by the latter, and disappears under débris and turf. Above it is a greyish limestone, at most only subcrystalline in aspect, and retaining traces of organisms, as already noticed. Higher up is a small outcrop of

a whitish rock, more like the marble in a very crushed condition than a Jurassic limestone; next comes indubitable Jurassic limestone, and lastly gneiss. In one place the top of the lower mass of marble could be seen within a few inches of dark shaly Jurassic rock. On the eastern side of the Pass two small pits had been opened since the author's last visit; they also showed the top of the marble underneath the Jurassic rock. Both rocks were rather shattered near the junction, but were as different as they well could be. The one resembles the marble, associated elsewhere in the Alps with crystalline schists; the other, a member of the Jurassic system. There is not the slightest sign of a passage between them, but much to suggest faulting. The field evidence is confirmed by study, macroscopic and microscopic, of the specimens. Accordingly the author adheres to the view already expressed, that the white marble is a rock much older than the Mesozoic era.

2. "Geological and Petrographical Studies of the Sudbury Nickel District (Canada)." By T. L. Walker, Ph.D., M.A. (Communicated by J. J. H. Teall, Esq., M.A., F.R.S., Sec.G.S.)

Sudbury is a small town situated in Northern Ontario, in the centre of the nickel-mining district. North of the Great Lakes granite and gneiss form almost boundless terranes, interrupted only by belts of Huronian rocks, which are in turn associated with post-Huronian eruptives, the most important of which are the large nickel-bearing massives.

The Huronian rocks in the vicinity of Sudbury were examined by Professor Bonney, who published his results in the Quarterly Journal of this Society (vol. xliv, 1888). These rocks form a large belt extending from the northern shore of Lake Huron north-eastward for several hundred miles. In the immediate vicinity of Sudbury they are composed of quartzite, mica-schist, phyllite, slate, volcanic breccia, and greywacke.

Far more interesting are the nickel-bearing rocks, which are eruptive and form long elliptical stocks which conform to the strike of the Huronian rocks containing them. Contact-action indicates that they are younger than the rocks previously referred to. The smaller eruptives are composed of greenstone, which appears to have been formed from norite or gabbro. Some of the larger eruptives, however, have been highly differentiated on cooling, as they are now composed of granite and greenstone with gradual transitions from the one to the other. The greenstone generally forms one side of the eruptive, and on the outer border is often characterized by large masses of nickeliferous pyrrhotite, chalcopyrite, and nickeliferous pyrite, with frequent smaller masses of magnetic iron-ore rich in titanic acid. The writer regards these mineral masses as genetically related to the greenstone and granite, in that they appear to be the extreme products of differentiation. About half the world's nickel supply is drawn from these deposits.

The greenstone is generally somewhat altered, but at times it is only slightly changed, when it is seen to be typical norite.

The alteration of augite and hypersthene is described in detail,

and the term "migration" is suggested for the process in which secondary hornblende is formed in plagioclase, as if bastite-substance had been carried in solution along the cleavage-lines of the felspar and by reacting upon its host had produced secondary hornblende. Hornblende so formed is referred to as "emigrated hornblende." Areas of uralitic hornblende generally extinguish under crossed nicols in two portions. On a very favourable section it was possible to determine that the two portions of hornblende are in definite crystallographic orientation—namely, that of twinning on the orthopinacoid, as is common in hornblende-crystals.

A mineral resembling wöhlerite was found to be relatively abundant in some of the more acid rocks of the Windy Lake eruptive.

The nickeliferous rocks are cut by younger eruptives—stocks of granite and dykes of olivine-diabase.

A few pages are devoted to the subject of differentiation, in which it is pointed out that no one of the generally accepted theories is able to account for all the phenomena observed in the differentiation of the nickel-bearing rocks of the Sudbury district. Stress has been laid upon the part which gravitation undoubtedly plays in producing heterogeneity in eruptive rocks. All the old theories of differentiation are directed to explain the presence of basic borders on more acid central portions, while they do not account for those cases where the central portions of stocks are basic and the margin acid. They fail also to give any explanation of the commonest case, namely, the eruptive showing little or no differentiation. These different cases are not only explained, but predicted, by the application of the principle of gravitation to slowly-cooling eruptive magmas.

3. "On the Distribution in Space of the Accessory Shocks of the Great Japanese Earthquake of 1891." By Charles Davison, Sc.D., F.G.S.

The object of the author in this paper is to consider the geographical distribution of the numerous shocks which preceded and followed the great earthquake of 1891. A brief summary of Professor Ōmori's work on the distribution of the after-shocks of this earthquake is given, and the difference between his method of treatment and that adopted in the present paper pointed out; the author furthermore indicates possible sources of error in his maps, and explains how these may be practically neglected.

In a map of the coast within the Mino-Owari district, the boundary of the area over which the principal shock was felt is enclosed by a line which bifurcates towards the south. The longer axis of this area coincides generally, as shown by Professor Koto, with the direction of a fault-scarp which, however, is only prolonged into the south-eastern fork of the disturbed area. This the author speaks of as the main fault, and he infers the evidence of a secondary fault running along the southern fork.

In discussing the preparation for the great earthquake, reasons are given for believing that the distribution of earthquakes in

1890–1 was little, if at all, due to the marked shock of May 12, 1889, but that the earthquakes of these years were preparatory to the great earthquake, the consequent relief at numerous and widely distributed points equalizing the effective strain along the whole fault-system, and so clearing the way for one or more almost instantaneous slips along its entire length. This outlining of the fault-system points to the previous existence of the faults, and implies that the great earthquake was due not to the rupturing of the strata, but probably to the intense friction called into action by the sudden displacement.

The distribution of the after-shocks is then discussed, and it is maintained that the after-shocks of the Mino-Owari earthquake for the first fourteen months were subject to the following conditions—decline of frequency, decrease in the area of seismic action, and a gradual but oscillating withdrawal of that action to a more or less central district.

Professor John Milne, F.R.S. (who has lately returned from Japan and intends now to reside in this country), said that the Mino-Owari earthquake had furnished a greater number and a more varied series of seismic phenomena for analysis than had been noted in connection with any disturbance previously recorded. When this earthquake took place an enormous fault, which can be traced over a length of more than forty miles, appeared upon the surface, and it was usually supposed that the sudden rupture and displacement of vast masses of material along this line were the cause of the earthquake.

On account of a peculiar distribution of shocks which took place prior to 1891, Mr. Davison argued that the fault or faults in the Mino-Owari district were outlined before the occurrence of the great earthquake, which was, therefore, only the result of their extension. This may have been so, but it must be remembered that before 1891 the number of shocks occurring in the Mino-Owari plain were not numerous; and as we pass from 1889 to 1891 we cannot say that they increased in number, while their distribution, as exhibited by maps, was largely dependent upon the observing-stations. Where the maps showed blank spaces, in many cases the country was mountainous, and there were no observers. The present author's method of treatment of the statistics relating to "after-shocks" no doubt possesses advantages over that previously used by Professor Ōmori, but the results arrived at, so far as they are comparable, closely accord. It was at the speaker's suggestion that the study of after-shocks was taken up, and he must congratulate Professor Ōmori at having obtained results far beyond and of greater importance than anything anticipated at the outset. Professor Ōmori added to our knowledge respecting the expiring efforts in a seismic area; while Mr. Davison, amongst other things, has thrown new light upon the change in subterranean conditions which culminated, on October 28, 1891, in a shaking which could be recorded from pole to pole.

CORRESPONDENCE.

CALAÏS NEWBOLDI.

SIR,—Since the publication of my paper "On a Fossil Octopus (*Calaïs Newboldi*, J. de C. Sby. MS.), from the Cretaceous of the Lebanon," in the Quart. Journ. Geol. Soc., vol. lii, p. 229, 1896, I find that the name *Calaïs* has been twice used—first by F. L. de Laporte in 1836 (Silbermann, *Revue Entomologique*, vol. iv, p. 9) for a genus of COLEOPTERA; secondly by J. A. Boisduval, also in 1836 ("J. A. Boisduval, Species Général des LEPIDOPTÈRES," vol. i, p. 584; quoted as a synonym of *Idmais*, Boisd.). Under these circumstances it becomes needful to propose a new generic name for Sowerby's *Calaïs*; I would therefore suggest that the name of *Palæoctopus* replace that of *Calaïs*, which is preoccupied by a genus of COLEOPTERA.

HENRY WOODWARD.

LIFE-ZONES IN CARBONIFEROUS ROCKS: A CORRECTION.

SIR,—I observe that in your last number (p. 519), the British Association Report on Life-zones in the British Carboniferous Rocks is stated to have been drawn up by me, whereas it was the work of the Secretary, Mr. E. J. Garwood.

JOHN E. MARR.

70, HUNTINGDON ROAD, CAMBRIDGE.

LINNÆUS ON THE APPENDAGES OF TRILOBITES.

SIR,—In the May number of the *American Geologist*, Dr. C. E. Beecher has published an article entitled "On a Supposed Discovery of the Antennæ of Trilobites by Linnæus in 1759." As this article refers to my short communication to the GEOLOGICAL MAGAZINE, p. 142, March, 1896, I shall be glad if you will afford some space for a few remarks in reply to the interpretation of Linné's figure proposed by Beecher.

To begin with, I regret that, in the introductory words, I have used so inaccurate an expression as to suggest that Linné's paper had been overlooked ever since its first appearance, while I have only taken into consideration the period which I have spoken of as a time of important researches into the ventral structure of Trilobites.

Beecher sums up his reasoning concerning the organs, regarded by Linné as antennæ, in the following terms: "It necessarily follows that the cephalon of the specimen figured by Linnæus is without free cheeks, and with this interpretation of the figure, the supposed antennæ can only be homologized with the thickened border between the points where the facial suture cuts the anterior margin." This conclusion is drawn under the supposition that the disputed organs are not antennæ, but no conclusive evidences are adduced that they are not. Before entering upon an examination of Beecher's arguments, I think it suitable to give a short review of the modes in which the head of *Parabolina spinulosa*, Whalb., is

usually found preserved. In the zone which is characterized by this fossil, it occurs in the greatest profusion; but owing to the friability of the matrix, it is often difficult to protect the specimens from destruction when kept in collections. Entire heads are not rare, but they more commonly display only the central shield between the facial sutures; other specimens present the same part, but with the portion situated before the glabella and the ocular ridges broken off. That the free cheeks are wanting in the specimen figured by Linné, I have so much the less reason to doubt, as I have in my own collection heads of *Parabolina* quite agreeing with the Linnean figure, but for the parts there visible before the glabella. The free cheeks are indubitably absent for the greater part, but a small portion of them behind the eyes seems to be coherent with the fixed cheeks, since the outer margin of the whole presents an uninterrupted curvature, just like that seen in Linné's delineation. I cannot explain the cause of this shape; it may, perhaps, be due to the form of the inflected portion of the free cheeks. However, a further examination of Linné's drawing does not confirm Beecher's suggestion as to the nature of the parts which Linné called antennæ. If these were to be interpreted as the thickened border between the facial sutures, they ought not to have been pointed towards the end, nor to have been so long as they are. These circumstances might, however, be considered as depending upon carelessness of the draughtsman; and I should scarcely have mentioned them, if they had not been combined with another detail, which cannot be accounted for as due to such carelessness. Before the frontal lobe of the glabella there is a smaller rounded lobe projecting between the pieces in question, which is not only a little larger, but also more distinct in the original figure than in Beecher's reproduction. The form of this lobe seems to me to preclude the idea that we have before us the thickened frontal margin. But if we imagine the foremost part of the central shield before the glabella to be broken off, as is often the case, there is another part which has just that position, quite the same shape, and the same size as that lobe, viz. the anterior part of the hypostome, or, more strictly speaking, of its central portion. This organ is very often met with amongst the specimens imbedded in the slates. From beneath this lobe the antennæ appear springing forth, and their bending can easily be imagined continued beneath the hypostome, to their points of attachment at the sides of the same.

Though I think this interpretation to be more in harmony with the Linnean figure, I admit that the question is not so clear as could be desired. But I believe I am fully justified in having directed the attention of scientists to this early mention of antennæ in Trilobites, each palæontologist being, of course, entitled to attach just as much importance to it as his conviction demands.

By several expressions in Beecher's paper, I feel called upon to repeat from my earlier communication that "this reference to an old"—and isolated—"observation, can by no means abate anything

of the value of the brilliant discoveries of our days" made by the eminent palæontologists cited by Beecher, or by that distinguished investigator himself.

Sv. Leonk. Törnquist.

Lund, *September*, 1896.

ANGLESEY AGGLOMERATES.

Sir,—In his short paper in your current (November) [1] number, Sir A. Geikie is very ready to give up his opinion as to the agglomeratic character of certain fragmental rocks in Anglesey, but I hope my own opinion was based on too solid a foundation to be so easily overthrown. After reading this retractation, I turned to Sir A. Geikie's and my own original description of these agglomerates, quoted below, and it appeared to me at once that if the phenomena in the Isle of Man were the same as in Anglesey, the rocks in the former locality could not be "crush-conglomerates." I therefore turned again to the description of these "crush-conglomerates" as given by Mr. Watts, and this is what he says:—"The fragments exhibit a great uniformity in composition, and nothing has hitherto been found in them but grits and slates," which "could all be matched either in the transition series or else in the main grits and slates" (between which the crush has taken place). "Although Mr. Lamplugh was alive to the importance of looking out for the existence of fragments of igneous rocks and other strangers, and collected a number of specimens to be tested with this point in view, not a single fragment of any other rock has up to the present been detected." [2]

We cannot doubt that Sir A. Geikie is equally alive to the importance of this feature, and, indeed, his new descriptions of the rocks in Anglesey indicate as much, but I think in his enthusiasm he must have forgotten his older, fuller, and, I think, more accurate account of them. This is what he first said about the rocks at Llangefni: "The agglomerates . . . contain abundant blocks of reddish quartzite, pieces of various felsites and of finely amygdaloidal andesites." [3] My own statement is practically identical: "They contain huge masses of quartzite and igneous rocks." [4] These are certainly not descriptions of the rocks of the neighbourhood between which the crushing could have taken place. Sir A. Geikie *now* writes: "The strata affected appear to have been originally shales or mudstones (with possibly some fine felsitic tuffs), alternating with bands of hard siliceous grit." [5] These two descriptions are very different. Can Sir A. Geikie reconcile them?

Of the rocks near Cemmaes he originally wrote (of the vent on Mynydd Wylfa): "It is filled with a coarse agglomerate, among the large blocks in which fragments of quartzite, limestone, felsite, grit, and shale may be noticed" (five varieties of rock); and the vent on the west side of Cemmaes harbour "appears to have been drilled

[1] Geol. Mag., Dec. IV, Vol. III, p. 481.
[2] Q.J.G.S., vol. li, p. 591.
[3] *Ibid.*, vol. xlvii, p. 130.
[4] *Ibid.*, vol. xliv, p. 487.
[5] Geol. Mag., Dec. IV, Vol. III, p. 481.

through some of the thick limestone bands of the district. Large masses of vertical and crumpled limestone beds, as well as quartzite, have been caught up in the agglomerate, together with abundant blocks of grit, fragments of shale, and pieces of a pale felsite"[1] (five varieties again). Of the vent at Porth Cenal my own description is: "The most remarkable feature is the occurrence of great quartz lumps, which are of all sizes and shapes, and lie promiscuously in an agglomerate of slates, grit, and dust," and, "in the headland of Pen-y-parc we get another agglomerate of quartz lumps and ash"; and, after observing that these rocks (the limestone not being mentioned as being merely torn from the sides of the vent) are not those of the immediate neighbourhood, I added: "We cannot here refer [these agglomerates] to the action of a crush-fault,"[2] a remark which shows that I was not unaware of this alternative. These descriptions, with the interchange of "felsite" and "ash," are fairly consistent, but Sir A. Geikie's new description is: "The huge blocks of limestone, there to be seen isolated among fragmentary grits and slates, are referable to the disruption of some of the limestone bands which occur abundantly in the neighbourhood" (quite so). "A gradation may be traced from the slates and grits outside the areas of more severe dislocation into the intensely crushed and sheared 'agglomerate.'"[3] Where is here the quartzite, and the felsite, and the drilling?

The fact is that one main reason, amongst others, in my mind at least, for calling these Anglesey masses agglomerates, was the occurrence in them of a variety of rocks not like those of the immediate neighbourhood; while the main reason for believing the Manx rocks to be "crush-conglomerates" is that the rocks in them are of those kinds only which occur on either side of the area of crushing. The phenomena in the one case are, therefore, not the same as those in the other. J. F. Blake.

November 4, 1896.

THE OLD RED SANDSTONE OF SCOTLAND.

Sir,—Regarding the statement of Professor Davis in last month's issue of this Magazine, it gives us great pleasure to receive his explanation that the terms Devonian and Old Red Sandstone had been used synonymously in his paper, and not as representing two distinctly different conditions of deposit. But he must be well aware that this loose application of these two terms has long fallen into disuse in British geology, and that they now stand for two different types of deposit. Hence it was quite natural for anyone reading his footnote to suppose that his "Devonian erosion" refers to his notice of Sir A. Geikie's plain of marine denudation given in the body of the paper; while his reference to the Old Red Sandstone stands for something quite distinct. Further, as he says himself, having been principally indebted to "English writings" for his knowledge of the structure of this country, we thought it

[1] Q.J.G.S., vol. xlvii, p. 134.
[2] *Ibid.*, vol. xliv, pp. 517-8.
[3] Geol. Mag., Dec. IV, Vol. III, p. 482.

but fair to consider he had been led by Sir A. Geikie's description of the succession of physical events in Scotland after the plication of the earlier Palæozoic rocks, to infer that there had been two distinct periods of denudation, the one marine and the other fresh-water. We sincerely trust that this explanation will be acceptable to Professor Davis of the reading we placed upon his footnote.

But let us now turn to the much more important subject: Is there any evidence of two distinct periods of denudation—a marine, to which the plain of marine denudation is to be referred, and a fresh-water, to which the Old Red Sandstone deposits are to be assigned? Professor Davis, at least on this point, evidently believes that there must have been a vast denudation prior to the deposition of the Old Red Sandstone deposits, and that this denudation may have taken place without leaving any trace of its deposits. But he does not decide as to whether this denudation was subaerial or marine. If he believes that a vast subaerial denudation took place partly previous to, and partly contemporaneous with, the deposition of the Old Red Sandstone rocks of Scotland, then we are at one with him. But if, on the other hand, he believes with Sir A. Geikie, that a great marine denudation took place which has left not a "rack behind" in the shape of deposits, but is only represented by a plain of marine denudation, then we beg to express our dissent.

It seems to us Professor Davis takes but a partial and limited view of the structure and relationship of the Scottish Old Red Sandstone to the older Palæozoic mountain-chain. He states that the Old Red Sandstone lies unconformably upon the floor of ancient rocks. This is doubtless correct so far as the Moray Firth area, and all Old Red Sandstone areas north of the Grampians, are concerned; but had he extended his traverse of the Old Red Sandstone to the boundary fault between Ayrshire and Midlothian he would have found that the Old Red Sandstone conformably succeeds the Silurian of these districts. It is here, in our view, where the *missing link* is found. With Ramsay, Geikie, and others, Professor Davis seems to overlook the significance of this important fact. In this connection a feature of some interest may be referred to. In Lanarkshire a band of shale about 5,000 feet above the base of the Old Red Sandstone contains *Orthoceras dimidiatum*, *Spirorbis Lewisii*, and a graptolite. These being unquestionably Silurian fossils, may not this band of shale and underlying sandstones, conglomerates, etc., be the equivalents of the Downton Sandstones? Again, we have shown that the Caithness rocks must be assigned to a higher horizon than those of Strathmore, while we think we have given strong evidence, both physical and palæontological, for believing that the whole of the series from the passage beds of Lanarkshire, through the middle series of Strathmore, into the highest members of the group in the Orkney Islands, are of marine origin; and it is to this age we would refer the plain of marine denudation seen in the Highland mountains.

Professor Davis advances two objections to the plain now seen

in the Highland mountains being of such high antiquity as we have given it — first, that it could not have survived the subsequent deformation, as seen in the angles to which the Old Red Sandstone has been tilted; and second, that it can hardly have been longer exposed to dissection than since the latter part of Mesozoic time. Now if Professor Davis takes a geological map of Scotland and examines it, he will find two great faults running across Scotland: within these faults he will find the later Palæozoic rocks tilted and crushed at considerable angles, this being an area of faulting and corrugation; outside these faults, however, the later Palæozoic rocks lie at low angles, showing little evidence of disturbance, and we believe not enough to destroy the old marine peneplain. On these areas the later Palæozoic rocks, including both the Old Red Sandstone and the Carboniferous series, lay piled in their almost normal horizontal position, to the height of thousands of feet, and so preserving the old marine peneplain from the action of the subaerial forces which otherwise must have destroyed it; and presenting it as we see it at the present day. It was upon this cover of horizontal rocks, we believe, the river systems of the Highlands were first traced. P. Macnair and J. Reid.

THE STRUCTURE OF GLACIER-ICE.

Sir,—When at Chamonix on September 24, 1896, I visited the Glacier des Bossons. At the termination of the glacier, where the stream was flowing out, the ice was melting in a most interesting manner, which fully bears out the description and drawings of the structure of glacier-ice (by polarized light) given by Messrs. Deeley and Fletcher in the Geological Magazine, 1895, pp. 152–162. The ice was disintegrating into separate pieces of irregular form, each an inch or thereabouts in diameter (there may have been larger and smaller pieces), and fitting exactly together, with interlocking projections and cavities, so that the structure reminded one of a toy dissected map. Here, then, we have the glacier-ice dissected for us by nature and its structure displayed to the naked eye, without the aid of a polariscope. As I had no polariscope with me I cannot say whether each piece consisted of a single crystal or of an aggregate of crystals. Bernard Hobson.

P.S.—Perhaps by immersing blocks of glacier-ice in hot water the structure might be brought out artificially.

THE JUBILEE OF THE PALÆONTOGRAPHICAL SOCIETY: A SUGGESTION.

Sir,—On reading the interesting account of the work of the Palæontographical Society that appeared in your valuable Magazine, it occurred to me that the jubilee of this Society might well be commemorated in some way more useful and more permanent than the eating of a dinner. The practical proposal that I now beg to offer is the outcome of considerable use of the volumes issued by the Palæontographical Society; for that has led to the discovery

of a great need. The need is that of a serviceable index to each or all of the completed monographs. Personally I have felt the absence of such a help most sorely in Davidson's large work on the Brachiopoda, and have wasted much time in searching for such well-known British species as *Productus Martini* or *P. productus*, *Lingula Voltzii*, and *Hemithyris angustifrons* (I mention examples from the last two days only). My colleagues say that equal difficulty is experienced with other monographs. We shall perhaps be told that indices are already published to these monographs; that may be, but they rarely contain what one wants, and some of them are not even arranged in alphabetical order. The proposal, then, is that a real index should be compiled to all the volumes as yet published by the Palæontographical Society; that it should contain every name mentioned, either in the text or in the explanation to the plates, whether synonym, variety, species, or genus; that these names should be arranged alphabetically under both generic and trivial names; that the index should be compiled by some experienced person or persons; that it should be published in octavo form, two columns to a page, certainly not in quarto form, and not on thick paper. The cost of preparing and publishing such an index might be defrayed partly by special subscription, partly by substituting it for a portion of the volume for one year. Most scientific men, including the members of the Palæontographical Society, would probably be more grateful for a good index than for another instalment of new species. By publishing this letter in your widely-read Magazine, you will perhaps elicit the views of geologists in general, and the Council of the Palæontographical Society would see what support was likely to be forthcoming.

F. A. Bather.

OBITUARY.

CAPTAIN MARSHALL HALL.

Born February 6, 1831. Died April 14, 1896.

Marshall Hall, late Captain in the Royal East Middlesex Militia, J.P. for Wilts, F.G.S., F.C.S., etc., was born in London on February 6, 1831, and died at Parkstone, Dorset, April 14, 1896.

As the only child of an eminent physician and physiologist, he was brought up in an atmosphere of science from early days, and it is to this circumstance that his *penchant* for things scientific was in a great measure due. Thus, he was at all times very handy with his microscope, which he found useful both in his chemical and mineralogical investigations. Besides an interest in science, mountaineering and yachting had strong attractions for him, and it was these three factors which largely influenced his career.

No one science could claim his exclusive allegiance; but he evinced an interest in Geology when he became a Fellow of the Geological Society in 1866, most probably at the suggestion of his

intimate friend, Morris. Shortly after taking this step a brief notice from his pen, in the GEOLOGICAL MAGAZINE, showed that he had already begun to interest himself in the glaciers of Norway, as he claimed to have made a rough survey of ice-tracts at the end of fjords where no yacht had ever been seen before.

Probably the best thing that Marshall Hall ever did for scientific investigation was by organizing the cruise of the "Norna" in 1870. It is true that on this occasion he was ably seconded by two remarkable men, Saville-Kent and Edward Fielding; to the former of whom especially the scientific credit of this most successful essay in marine zoology was due. Still, it was on the initiation, and mainly at the expense, of Marshall Hall that these results were obtained; and they are all the more striking when we remember that this expedition took place three years before the "Challenger" started on her memorable voyage.

A few years afterwards (1874) we find Marshall Hall, still full of enthusiasm, making a proposal in the GEOLOGICAL MAGAZINE for a "Swiss Geological Ramble"; and he asks the then President of the Geologists' Association (Dr. Woodward) what he would think of this extended excursion. Two years subsequently he was busily engaged, in conjunction with Sorby, Haughton, Heddle, and others, in founding the Mineralogical Society. The first contribution to the Journal of that Society (August, 1876) is a short note written by himself and Clifton Ward "Upon a portion of Basalt from the Mid-Atlantic."

From time to time he contributed short papers to the Mineralogical Society, not forgetting to suggest collaboration amongst mineralogists. As he was now for the most part resident in Switzerland, the rocks of the Val d'Anniviers and the Saasthal supplied him with a congenial theme. Here both his chemical knowledge and his climbing propensities were of use. Thus, in 1882 he narrates how he traced certain euphotides and serpentines to an *arrête*, some 10,000 feet high, descending from the Allalinhorre, and he compares the rocks thus observed *in sitû* with transported masses occurring in the neighbourhood of Veytaux and Geneva.

More recently, and since he came back to England, Marshall Hall returned with renewed ardour to an old love—the study of glaciers. His Alpine experiences helped him here. In this connection his friend and *collaborateur*, Professor Forel, writes[1] that Hall had often contributed original notes to the reports on glacial variations issued by himself. Later, in 1891, when living at Parkstone, Marshall Hall continued to follow up this subject with great eagerness, and obtained from the Alpine Club the formation of a committee charged with the care of studying the oscillations of the glaciers in different parts of the British Empire. In 1893 he contributed a short paper to the GEOLOGICAL MAGAZINE on "Glacier Observations, more especially Colonial," being the substance of two articles which had already appeared in the *Alpine Journal*. He was successful also in interesting the Colonial authorities in his scheme.

[1] "In Memoriam": Alpine Journal, August, 1896, p. 176.

Finally, in 1894, at the International Geological Congress of Zurich he initiated the formation of the "Commission Internationale des Glaciers," being himself elected representative for Great Britain and the Colonies.

A wide field had in this way been found for the exercise of his energies, and there seemed every prospect that he might continue to do much good work, when, to the great sorrow of his family and numerous friends, he was carried off, after a short illness, at the age of 65, just as his plans for the universal study of glacier action were beginning to bear fruit.

Marshall Hall is not to be estimated merely by his writings, which, like his speeches, were for the most part exceedingly brief. His strength rather lay in his faculty of bringing men together, and for this purpose his genial disposition and agreeable manners eminently qualified him. In the heyday of life he discharged these functions in a generous and hospitable spirit. Unfortunately, as time went on, his physical infirmity of deafness, in conjunction with other causes, tended to withdraw him from society at large, though never from social intercourse. To the last he struggled bravely against all these difficulties, frequently busy, but, as he says in a letter written a few months before his death, grown older and less inclined to work. "Not that I am often idle," he remarks; "things come in all of a heap, then comparative repose, then more work. There will not be much to show for *sundry years*, even if I got folks to do anything systematic. So far, the New Zealanders are my best men."

Those *sundry years* he was not destined to realize, and now that the originator is gone will the work be continued?

HENRY JAMES SLACK, F.G.S., F.R.M.S.

BORN OCTOBER 23, 1818. DIED JUNE 16, 1896.

AMONG the pioneers of science, more especially interested in the promotion of microscopical investigations in Biology, the name of Henry James Slack must be engraved upon the annals of the present century, of which his life had covered nearly 78 years.

H. J. Slack was educated at Dr. Evans' school, North End, Hampstead, and at the age of seventeen he entered a wool-broker's office in the City, in which he speedily became a partner, but he retired in 1846, finding the business uncongenial to his literary and scientific inclinations: he then devoted himself to legal and forensic studies, and was in due course "called," but although a keen debater, and intensely fond of either a scientific or political discussion, he never practised at the Bar.

Whilst residing at Ilfracombe, in 1849, he wrote several articles which appeared in the *North Devon Journal*, and in 1852 he became proprietor and editor of the *Atlas* newspaper, to which Walter Savage Landor contributed some poems on Garibaldi. He also acted as temporary editor of the *Westminster Quarterly*; and contributed numerous articles both to newspapers and other

periodical publications. In 1860 Henry James Slack commenced to write leaders for the *Weekly Times*, which he continued until 1884.

Keenly alive to all political and social reforms, and spending his time and money most generously in the cause of national and unsectarian education, he was at the same time earnestly devoted to scientific pursuits. He joined the Geological Society of London in 1849 (having been at the time of his death a Fellow for 47 years). Among his numerous scientific papers three only bear directly on Geology, namely: "On Coccoliths and Coccospheres in Reigate Sandstone"; "Notes on the Comparative Geology of the Earth and Moon"; and "Life Changes on the Globe."

One of his most valuable labours for the promotion of science was the editing of *Recreative Science* (published by Messrs. Groombridge and Sons), which was enlarged successively into the *Intellectual Observer*, and lastly into the *Student*. As the popular exponent of science, this periodical occupied, for about twenty years, a first-class position, and possibly might have survived even to the present day, but for the triple dangers of alterations *in form*, *in size*, and *in title*, which it underwent at the hands of its metamorphotic publishers and editor, had not the former terminated their publishing business, and the latter his duties as editor! Dr. S. P. Woodward, Dr. G. S. Brady, Dr. P. Lutley Sclater, Dr. H. Woodward, Dr. P. Martin Duncan, Dr. Wright, Professor Sir Wyville Thomson, and many other distinguished men of science, contributed to Mr. Slack's monthly magazine, and its pages abounded with good scientific articles.

Of the Royal Microscopical Society he may be said to have been one of the founders, and he filled in succession the offices of Secretary and of President. In addition to the keen interest which Mr. Slack took in all microscopical research, he was also an enthusiastic student of Astronomy, and erected a telescope about 1867, at his residence in Camden Square, which had some points of novelty, being a Newtonian, mounted equatorially on a stand designed by Mr. Browning and himself, having a silver-on-glass speculum and a prism instead of a mirror at the eye-tube (see *Intellectual Observer*, vol. ix, p. 276). Always interested in politics and in all matters relating to education and social progress, and being a strong democrat in principles, in 1879, when President of the National Sunday League, he instituted Sunday Evening Entertainments for the People, giving popular scientific lectures himself, with illustrations, and always with selections of good classical music.

His scientific papers mostly appeared in the *Intellectual Observer* and *Student*, and bear chiefly upon microscopical research. Some of his work on Infusoria was published in a small book entitled "Marvels of Pond Life," which passed through three editions.

In later years Mr. Slack removed from London to a delightful country residence, Ashdown Cottage, Forest Row, Sussex, where he spent the last ten or fifteen years of his always happy, busy, literary and scientific life.

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